The
ENGINEERS' DIGEST

REVIEW OF WORLD ENGINEERING PROGRESS

VOL. XII No. 5. MAY, 1951

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CONTENTS

	Page
The Blue Pages	141
Plating and the Scarcity of Nickel	145
Optimum Lighting Economy in Buildings	146
The Efficiency of Heat Engines	149
The Physical Characteristics of D.C. Generators	152
Journal Bearings with Hydrodynamic Lubrication	154
The Study of Sintering Phenomena by Means of Continuous Contraction Measurements	155
An Aero-Electric Pilot Plant of Medium Power	158
The Design of Bearings for Piston Engines	163
British Industries Fair, 1951	165
Swiss Industries Fair, 1951	168
News of the Month	171

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A QUICK GLANCE AT THE LATEST TECHNICAL DEVELOPMENTS THROUGHOUT THE WORLD

● ***PROSPECTIVE USES OF RHENIUM***

Today, some twenty-five years after its discovery, several industrial applications of Rhenium appear to be in prospect, although commercial production of this metal is still limited. Outstanding properties of Rhenium are its high melting point of 3440° C abs. and the ease with which it can be alloyed with Tungsten, Nickel, Cobalt, Tantalum, Platinum, Rhodium, Iridium, Gold and Iron. Rhenium alloys are reported to offer excellent corrosion-resistant properties, and the high melting point should make Rhenium and its alloys an attractive material for electrical contacts. For pen nibs, an alloy containing 75 per cent Rhenium, 15 per cent Rubidium, 7·5 per cent Niobium and 2·5 per cent Beryllium has been proposed. It has been found that Iridium and Rhodium alloys are more easily worked if alloyed with 10 per cent Rhenium, the resultant alloys being suitable for drawing into fine wires and rolling into thin ribbons. The marked thermoelectric properties of Rhenium should make this metal an excellent material for thermocouples. Couples of Platinum-Rhenium and Platinum, of Platinum-Rhenium and Rhodium, or Iridium-Rhenium and Iridium, possess high electromotive forces and can be used at temperatures up to 1900° C, it is stated. Rhenium should also have important uses as a catalyst as, for instance, in the synthesis of methane.

● ***ELECTROSTATIC TRANSFORMERS***

An ingenious, surprisingly simple method for the voltage transformation of direct current is proposed in a recent British Patent Specification, which may prove very useful in electronic engineering applications where comparatively high d.c. voltages but only small currents are required. The new method utilises the fact that the voltage of a capacitor can be changed by first charging it at a given voltage while the space between the electrodes is occupied by a dielectric of high dielectric constant. By lowering the amount of capacitance and diminishing the effective dielectric constant, the original voltage will be multiplied accordingly. In order to obtain a high transformation ratio, one dielectric must obviously have as high as possible a dielectric constant. It has therefore been proposed to use barium titanate or lead zirconate which have very high dielectric constants, of the order of one thousand to ten-thousand. The other dielectric, which is to be used to lower the capacitance, and with it to increase the voltage, may be an oil, or air, or vacuum. The actual variation in voltage is accomplished in one proposed device by having two flat disc electrodes with the solid dielectric between them. One of the electrodes is held in permanent contact with the dielectric, while the other electrode is connected to a reciprocating mechanism which oscillates the electrode toward and away from the exposed face of the stationary dielectric. The necessary electrical contacts are also operated by the reciprocating mechanism.

● ***FREQUENCY TRANSFORMERS FOR SMALL MOTORS***

There are many industrial applications which call for the use of high-speed fractional horsepower electric motors of minimum weight and size. In general, the motor types employed to meet these requirements are either series commutator motors operating at network frequency, or normal induction motors operating at higher frequency, as, for instance, 200 cps, supplied by a special generating plant. Of these two motor types the induction type possesses the more desirable speed characteristic; also, maintenance of brushes and commutator does not arise with these machines. An undesirable feature, however, is the requirement of a special generating plant. In telecommunications and signalling, static frequency transformers are employed on a very large scale, but these have not yet found widespread use for the purposes of motor operation. A recent investigation of the possible uses of static frequency transformers for the operation of high-speed motors would therefore appear to deserve careful consideration. The investigation referred to included, firstly, frequency doubler circuits using various combinations of transductors and dry-cell valves, and, secondly, frequency tripler circuits using a three-phase transformer with a saturated core and an open secondary winding on the two outer limbs. The second method was subjected to a particularly searching investigation, partly because it seems to be more economical, and partly for the reason that the higher speed obtained by the application of the higher frequency produced is of considerable practical importance. It goes without saying that the efficiency of such units cannot be high, but in the majority of the applications concerned, neither efficiency nor unit cost will be of vital importance.

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● *INCREASING THE HARDNESS OF STAINLESS STEEL*

It has been announced that a new process has been developed whereby stainless steel can be made several times harder than has hitherto been possible. The process consists of a short heat treatment at 2100° F, quenching in water, cooling to minus 300° F, rolling from $\frac{1}{4}$ to $\frac{1}{16}$ in. and then ageing for several hours at the lowest temperature. It is claimed that tensile strength, yield stress and hardness are all increased by this process as compared to conventional rolling. A particularly interesting fact is that cold rolling tests were found to produce an increase in proportional limit about twice that obtained by rolling at room temperature. Torsional yield stress and fatigue strength were also increased by about one-half. It is further reported that one sample tested showed an even more remarkable characteristic. Austenitic stainless steels worked by conventional methods have very low wear resistance as compared with wear-resisting alloys. Yet one of the processed stainless steel specimens, which differed slightly in composition from the others, showed a wear performance equal to or better than the best wear-resistant alloys. Unfortunately, no particulars regarding the composition of this specimen have been published as yet, and additional information on this point will be awaited with great interest.

● *ALUMINIUM JACKETING FOR OUTDOOR PIPE LINES*

The use of aluminium foil for thermal insulating purposes has been known for a considerable number of years. It is now reported that an aluminium jacket has been designed, especially for the purpose of protecting outdoor pipes in power, chemical and other plants. This is claimed to represent the first permanent-type jacketing which entails both low initial cost and low application cost. The jacketing is provided with a 0·006-inch thick protecting sheet of aluminium which is corrugated for strength as well as for the purpose of facilitating forming around the pipe. No roll forming, such as is necessary with heavy non-crimped material, is therefore required. This new type of jacketing, which can be put on with aluminium strapping and seals, can be removed and reused. A moisture barrier is attached to the back of the jacketing to provide positive protection for the aluminium when it is used with alkaline insulating material.

● *SPACE HEATERS WITH IONISATION CONTROL*

A novel electric space heater which conditions indoor air by ionisation control is claimed to give relief to sufferers of asthma, chronic colds and hay fever. The efficacy of this device is said to be due to the fact that negative ionised air has a therapeutic effect on certain ailments. The provision of negative ions is accomplished without the production of objectionable ozone and nitrous oxide, and the device is arranged to filter out positive ions, while allowing negative ions to be carried into the room by the air currents passing through the unit. While the actual construction of the device is not divulged in detail, the makers state that one of the principal component parts of the heater is a pure nickel cloth which constitutes a negatively charged grid surrounding the heating element. The latter is made of nickel-chromium alloy. These heaters are rated at 1,000 watts or more, but for use in warm climates, where no heating is required, a 30-watt emitter with high-temperature platinum filament has been developed for the generation of negative ions. In this type of heater, the negative ions neutralise positively ionised dust and pollen as air is circulated through the unit.

● *GLASS FIBRE REINFORCED PLASTICS*

Glass fibre polyester laminates are a very suitable material where high mechanical strength and low weight are required. In the past, the use of such laminates, mouldings and reinforced sheets was limited by the fact that their mechanical strength is radically impaired on exposure to water or high humidity. In fact, these materials lose as much as 50 per cent of their flexural strength on immersion in water or exposure to high humidity for any extended period. According to a recent announcement, this difficulty has now been overcome by the development of a new manufacturing technique so that the improved material may serve as an excellent substitute for steel and light alloys in many cases. The new technique is based on recognition of the fact that, in the original method, the bond between fibres and the plastic was not strong enough to withstand the action of water. It was found that this weakness can be eliminated by applying to the glass fibre a size consisting of vinyl chlorosilane, followed by a wash with water. It appears that in this manner the silicone atoms in the vinyl chlorosilane molecules become tied to the glass, while the vinyl part of the size will react and participate in the polymerisation of the resin, so that an actual bond is formed between the glass and the plastic. Particularly promising applications of the new material are claimed to be refrigerator housings, electric stoves, washing machines, automobile tops, filing cabinets, etc.; these are in addition to a great many military uses.

● *AIR-DRYING PLASTIC PROTECTIVE COATING*

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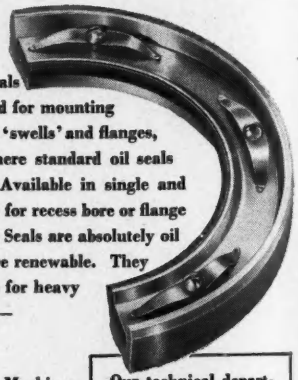

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new coating is expected to find its widest application in chemical processing, rayon and cellophane production, photo finishing, pulp and paper manufacturing, sewage disposal, filtering and electroplating, and in mining operations. It cannot be used in food processing because it imparts a slight odour and taste. This plastic combines high film flexibility with good adhesion and impact resistance. It is claimed that this plastic will not chip or crack and that it can be used on steel, aluminium, concrete, hardwood, or composition board. It is applied by spray, allowing one hour drying time between coats and 24 hours drying time after the final coat. It requires no primer and can be produced in a variety of colours. Since it contains no chemical plasticiser which would be subject to leeching out or hardening, the coat retains its flexibility throughout its service life. A sharp instrument will cut through the film, but the break can be repaired easily by touching up with brush or spray. Metal should be grit or sand-blasted before the coating is applied; cement should be etched with hydrochloric acid, while wood and composition board needs rough sanding to assure a good bond.

● *LIGHT ALLOY PIT PROPS*

Extensive trials with adjustable telescoping pit props of light alloy are reported to have given most satisfactory results and to have proved these props to be superior to timber props both from the structural and economic aspects. The design of the light alloy props employed in these tests was based on the requirement that the weight of the prop should not be greater than that of a timber prop and that it should support a normal load of 10 to 12 tons. To excess loads the prop should react by slowly telescoping, and actual failure should not occur at less than 20 tons compressive loading. As material, a precipitation-hardened Al-Cu-Mg alloy of 28 to 30 tsi strength and a yield point of 20 to 29 tsi was chosen. The upper part of the prop is made of two semi-oval tubes united at the top and telescoping within the lower part of oval section. Locking of the two parts is effected by driving a wedge into the clearance between the flat faces of the two semi-oval sections of the upper part so that they are held by friction within the oval section of the lower part. Above and below the point where the wedge is inserted, the lower part of the prop is reinforced by steel bands. This wedge-lock was found to take a compressive thrust of 7 to 10 tons before sliding and telescoping commences. The weight of the complete light alloy prop is given as only 24 lb as compared with a weight of 35 lb of an equivalent timber prop and 48-50 lb of a steel prop. Several thousand light alloy props are claimed to be now in successful service; the ease with which these props can be retrieved and used over again is said to make their use particularly attractive.

● *RECORDING MOTION OF WATCH BALANCE WHEEL*

Various devices are available for timing watches by recording the beats of the balance wheel with the use of a microphone and printing a dot on a moving paper tape for each beat of the balance wheel. An instrument has now been developed which provides a record of the actual motion of the balance wheel, i.e., curves of balance wheel angular displacement, velocity, or acceleration as a function of time. These factors are important insofar as the time-keeping qualities of a watch depend upon the degree to which the balance wheel motion approaches simple angular harmonic motion. The instrument developed provides a record of balance-wheel motion by recording the motion of the watch case, which is suspended from a wire so as to move freely about an axis parallel to that of the balance wheel. The case will evidently move in precisely the same manner as the balance wheel but in opposite phase and with an amplitude approximately equal to that of the balance wheel multiplied by the ratio of the moment of inertia of the balance wheel to that of the entire watch. For watches, this ratio approximates to 1 : 10,000, so that the amplitude of the watch will be in the order of 0·01 degree. In this device, the watch is placed on a pan suspended by a single fine wire, the pan carrying the movable secondary winding of an air-core transformer. The latter forms part of an amplifier circuit connected with a cathode-ray oscilloscope which allows visual observation of the aforementioned curves.

● *COMPRESSION-SIZED TUBING*

The economic advantages resulting from the use of seamless tube stock in place of bars or forgings in the manufacture of ring-shaped and similar steel parts are widely known. It is not, however, generally recognised that the actual savings achieved must necessarily depend upon the accuracy of the initial dimensions of the seamless tubing used. It would therefore appear that by using cold-sized tubing—cold-sized by a special compression process—a further reduction in machining costs can be achieved as compared to the use of ordinary cold-drawn tubing. American sources report that compression-sized tubing, in addition to being available with closer tolerances than ordinary cold-drawn tubing, is finer-grained, has a uniform microstructure, and has a depth of decarburization so shallow as to be negligible. These characteristics permit of machining the tubing at higher cutting speeds and feeds with consequent machining cost reductions of as much as 50 per cent, it is claimed. In compression-sizing, the tube metal is worked under compression, which causes it to flow both longitudinally and circumferentially. In this process, hot-rolled tubing is fed longitudinally through the compression-sizing machine and given a part-

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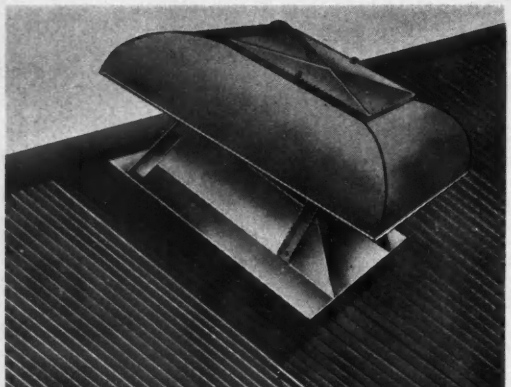

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turn on its axis to distribute work over the entire circumference. Semi-circular taper-grooved dies are rocked back and forth over the tube, compressing the wall against a tapered mandrel. Feeding into the machine is intermittent and timed to operate after the dies have completed their forward stroke. This process, which has been in successful application for a number of years, in certain respects bears resemblance to the original pilger process for the manufacture of seamless tubing.

● *ULTRASONIC FLAW DETECTION IN PIPES*

The application of ultrasonic flaw detection to the examination of tubes and pipes has hitherto been hampered by the fact that their annular cross-section does not lend itself to adequate inspection by means of normal ultrasonic methods. This applies in particular to cases in which the presence of radial cracks or folds is suspected. It is therefore a matter of considerable interest to note that a test procedure has now been perfected in which ultrasonic shear waves are employed for flaw detection. By definition a shear wave is one in which the particle motion is normal to the direction of travel, and in the case of a pipe the shear wave therefore travels circumferentially through the wall of the pipe, ricochetting, as it were, successively off the inner and outer pipe wall boundaries as it travels around. Flaw detection with the use of such waves rests upon the fact that a notch or flaw will produce a reflected wave which traverses the same path as the original wave, but in the opposite direction. In order to facilitate application of the search unit to all parts of the pipe, the latter is rotated at a speed of 5 to 10 rpm. In most cases very little cleaning of the pipe is necessary for the purpose of ultrasonic testing. Running a steel scraper over the surface will remove loose scale and raised spots of paint or tar. After cleaning, the pipe is coated with a heavy oil so as to allow the sound to be transmitted into the material. It is reported that tubes of diameters as small as $1\frac{3}{4}$ in. have been successfully tested.

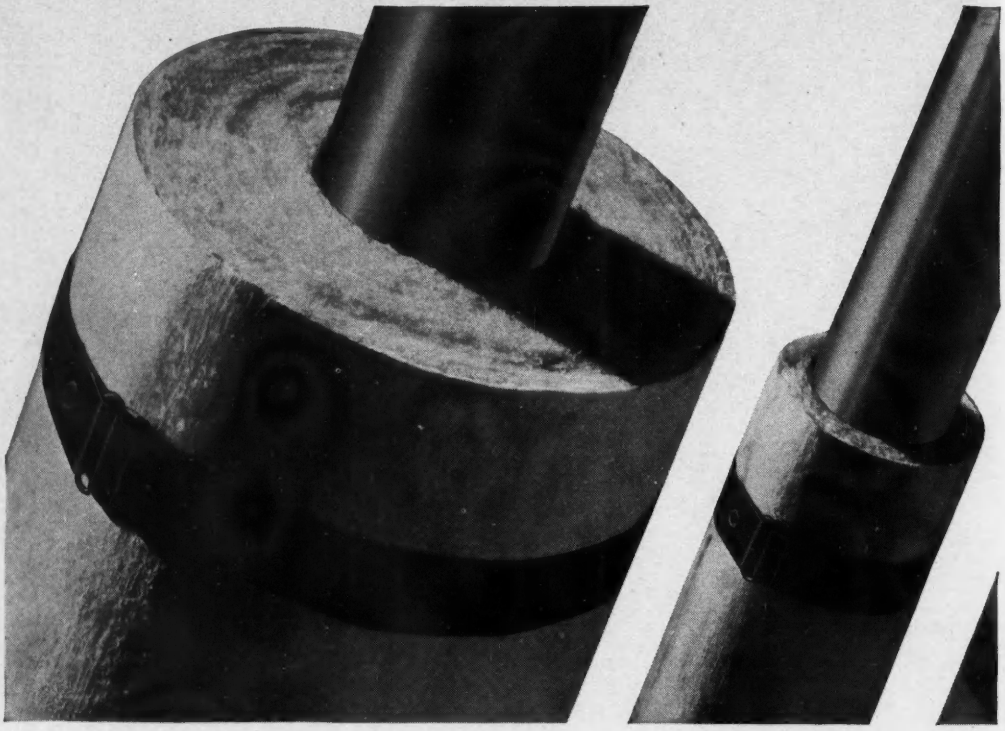
● *SMOKE ELIMINATION BY CATALYST*

A catalytic process for the elimination of smoke emission from boiler plants is reported to achieve remarkable results. In addition to ensuring more complete combustion, the process is claimed to increase heat transfer efficiency and to aid in keeping tubes and flues clean. Steam is taken from the boiler and passed through a small cartridge which contains a chemical of undisclosed composition and which is attached to the exterior of the boiler. The discharge end of the cartridge is connected to either a specially designed air jet or a steam-air jet spray in the combustion chamber. It is claimed that this system uses from 65 to 80 per cent less steam and air than is consumed by a normal type steam air jet. Ordinarily two jets, each using 55 pounds of steam per hour are used with one cartridge. The contents of the cartridge are said to be completely organic in nature and non-corrosive and non-harmful to the boiler. The reduction or elimination of smoke and increased efficiency result from a catalytic effect of the chemicals contained in the cartridge which speed up oxidation and lower the ignition temperature of hydrocarbons from 1135 to 630° F. It has long been said that, in any combustion process involving hydrocarbons, there is in effect a race between hydroxilation and cracking. If the cracking process is the faster one, formation of smoke results, while if hydroxilation, i.e., gradual absorption of oxygen by the hydrocarbons to form hydroxyl compounds, prevails, then no smoke is produced. One cartridge is said to give 34 days of continuous operation.

● *VENTURI BOOSTER ELIMINATES PUMP CAVITATION*

An interesting solution to the problem of pressure loss by cavitation at high pumping speeds consists in the provision of an input booster which has no moving parts. Operation of the device is dependent upon the difference in pressure between the static head and the velocity head in a venturi device. Fluid flowing through the restricting nozzle furnishes the velocity head, which would normally be below atmospheric pressure when entering the intake side of the pump, which may be of the gear, rotary vane, or centrifugal type. At this point connection is made to a supply and make-up tank vented to atmosphere. In consequence, the fluid in the throat is raised to atmospheric pressure, thereby creating a boost or supercharge at the intake side of the pump. By ensuring that atmospheric pressure is substantially maintained as the fluid enters the pump, the partial vacuum condition responsible for cavitation is prevented. A typical installation, on which brief information has become available, appears to be that of a gear-pump for a power steering mechanism for automobiles. To supply the minimum hydraulic pressure required at engine idling speed, the pump must be operated over a very large speed range, normally extending into the cavitation region. To obtain the desired minimum pressure and volume at low engine speeds, a smaller pump geared to operate at twice the engine speed was installed, while the venturi booster extended the permissible operating range of the pump by preventing the occurrence of cavitation at top speed.

For further information on developments reviewed in THE BLUE PAGES, readers are invited to write to the Editor.



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THE ENGINEERS' DIGEST
REVIEW OF WORLD ENGINEERING PROGRESS
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Plating and the Scarcity of Nickel

In a statement made in the House of Commons on April 20, the Minister of Supply, Mr. Strauss, referred to the shortage of nickel, molybdenum and tungsten and, consequently, of alloy steels. Although everything possible is being done to obtain greater supplies, savings in the civil use of these metals are immediately necessary to meet the very heavy requirements of the rearmament programme. Therefore, as an emergency measure, as from May 1, the amount of nickel available for stainless steel production has had to be reduced to 70 per cent of the 1950 level and that of anodes for plating to 50 per cent of the 1950 level. Less essential uses of nickel are prohibited.

The supplies of molybdenum are well below the 1950 level and there will be hardly anything left for civilian production. To supplement the imports of tungsten, the mining of tungsten ore will be started again in Devonshire.

Technical committees of the iron and steel industry have been set up to examine urgently what economies can be made in the use of nickel, molybdenum and tungsten, by modifying the specifications of alloy steels and working in co-operation with the alloy steel using industries. Furthermore, closer control of the distribution of nickel, molybdenum, tungsten, and alloy steels, will be required as soon as possible.

* * *

Similar prohibitions have already been enacted in the United States. The restrictions particularly affect the motor-car industries and those using nickel plating for non-essential products. It is, therefore, of interest to note that American industries have intensified their research efforts in order to develop new methods permitting continued manufacture of bright-plated parts. As our American contemporary " Steel " reports, a variety of methods has been applied with a view to reducing to a minimum the amount of nickel required for civilian applications.

* * *

A saving in nickel is obtained by applying stop-off lacquer on the backs of components where plating is not needed. The lacquer is then left on and reduces corrosion effects.

The use of nickel can be entirely eliminated for parts not exposed to weather or humidity. A copper layer of up to 0·001 in. is plated on the steel basis metal and carefully buffed to obtain a smooth surface. An 0·00002 in. flash of chromium is then applied. The plate is finally coated with a clear lacquer of about 0·0005 in. thickness, if necessary.

Chromium can also be flashed directly over chromium stainless steel. The material then has a corrosion resistance practically equal to that of chrome-nickel steel but tends to have a milky appearance. To avoid having to resort to a finish buff, United Chromium, Inc., has produced a high-speed self-regulating chromium solution which gives a bright surface.

Economy can be obtained by plating less nickel on more copper. For example, the thicknesses suggested for plating on a steel base metal are 0·001 in. copper, 0·0002 in. nickel, and 0·00001 in. chromium. Tests have indicated that nickel gives greater corrosion protection than copper. Although, in the above example, copper has been substituted for two-thirds of the nickel, plating thicknesses of between 0·0006 in. and 0·001 in. nickel may be required for high corrosion resistance.

The application of a coating of 0·0005 in. clear synthetic lacquer of the air-drying nitrocellulose type over 0·00001 in. chromium and 0·0001-0·0002 in. nickel on 0·0006 in. copper has also given good results. The corrosion-resistance is improved with urea-formaldehyde clear baked synthetics. By using coatings of this latter synthetic up to 0·001 in. thick, components can be adequately protected against high humidity conditions.

Another method is to electroplate a layer of zinc 0·0002 to 0·0005 in. thick directly on the steel, which is then dipped in a brightening and corrosion-resisting chromate type solution. The product is then coated with a urea-formaldehyde clear backing synthetic lacquer and has an attractive bright finish.

Colour finishes can also be used to good advantage, for instance, copper plate finished with clear baked synthetic. Chromium 0·0001 to 0·0002 in. thick can be deposited directly on steel and finished in a baked clear or tinted synthetic lacquer.

The above methods have been successfully applied to a wide variety of products, such as refrigerator shelves and interiors, bicycle components, kitchen utensils, steel panels, tubular furniture, motor-car radiator grilles, bumpers, hardware, etc. The nickel scarcity can thus provide the opportunity for trying out new methods and obtaining novel finishes with considerable sales appeal.

FINLAND

Optimum Lighting Economy in Buildings

By G. PLEIJEL. (From *Kraft och Ljus*, Vol. 24, No. 1, January, 1951, pp. 1-7, 12 illustrations.)

In H. Kreuger's dissertation, the problem of lighting economy is claimed to have been considered for the first time in its broader aspects, taking account of both artificial lighting and day lighting, and their relation to one another.*

THE conventional procedure is to determine first a minimum outdoor light intensity required for adequate visibility. The standard value varies between 3,000 and 5,000 lux in different countries. The standards used in Sweden are imported from more southerly latitudes, with the result that larger size windows are designed than would really be necessary in view of the climatic conditions of this country. The effects are not very satisfactory from the points of view of health, comfort and economy.

The proposed procedure is to base lighting considerations on two main factors, viz., "external light intensity" and "daylight ratio."

The indoor light intensity obviously depends on the external intensity, measured, for instance, in lux. This latter quantity is not easily determined, and it has been found convenient to introduce the concept of the daylight ratio, as a measure of the light intensity inside and outside a building, see Fig. 1. Admittedly, the concept is open to some criticism. However, as the indoor light intensity generally varies in the same way as the external intensity, the value of the daylight ratio will remain constant despite day-to-day variations of the external light. By using this ratio we eliminate any need to refer to the amount of sunlight, which is usually included in calculations.

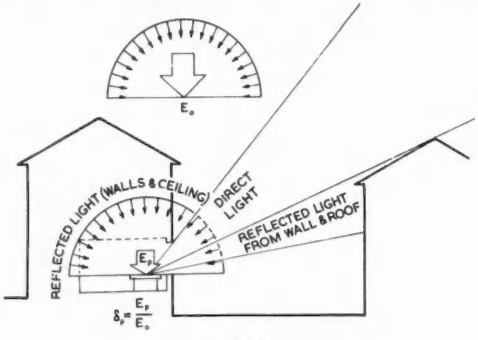


Fig. 1.

When calculating with mean values, taken, for instance, over a period of one month, the daylight ratio gives a good indication of the amount of daylight. Further evidence is still required, but, although various attempts have been made, no better expression has yet been proposed for practical purposes.

Kreuger first fixes the value of the indoor light intensity. Its value may differ in each case considered, according to prevailing conditions. This indoor intensity is to be maintained during the working hours, for instance, from 7 a.m. to 5 p.m., and is referred either to a type of daylight or to a type of artificial lighting. Fig. 2 shows the light variations during one day, for two values of the daylight ratio and two light intensities.

Fig. 2b shows the conditions with a daylight ratio of 10 per cent and an internal light intensity of 300 lux, for January and November. The working day begins and ends in artificial light. By increasing the window area to double its previous value, the daylight ratio is increased to 20 per cent, see Fig. 2a, with the result that the proportion of artificial light decreases and that of the daylight increases. Although less artificial lighting decreases the lighting costs, these go up again owing to the considerable installation, maintenance and operating costs for the larger windows, and the question whether these are advantageous or not has to be determined for each case.

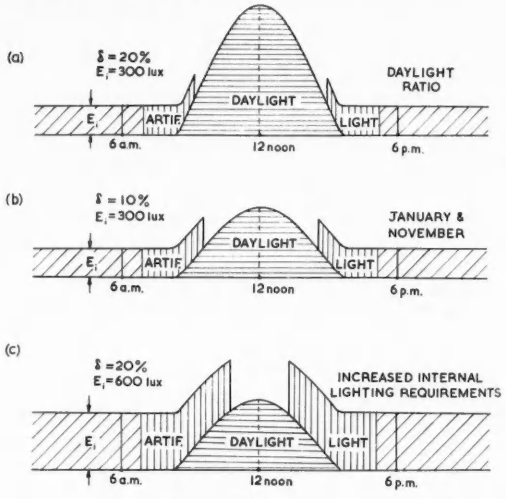


Fig. 2.

Fig. 2c shows the different conditions which prevail when the indoor light intensity is doubled. Obviously the cost of the artificial lighting is correspondingly greater, but the total heat losses through the windows remain constant. Moreover, increased lighting should result in greater productivity. There is a limit, however, beyond which no further increase in output is obtained. Kreuger mentions this subject as requiring further consideration. The logical consequence is, nevertheless, that any reduction considered in the indoor light intensity should reach an optimum value which does not affect the workers' output.

Similar considerations apply to the "excess light intensity," that is, the amount by which, during some hours of the day, the actual value of the daylight intensity exceeds the required internal light intensity. The light intensity variation is most noticeable during February, March, September and October, during which months the effect of this variation on output can be appreciable. Furthermore, even if the windows are so situated that they do not require painting over during the summer period to avert the heat, the excess daylight in the summer months may also affect the output. Generally speaking, to maintain the temperature at a suitable level, cooling arrangements can be used, but painting over of the windows is required to reduce the excess daylight in June, July and August unless the windows are situated in positions where this is not necessary.

*This article, from a paper read before the Finnish Society for Illumination Engineering, is based on a dissertation presented by H. Kreuger at the Technical University of Stockholm, and includes comments by Mr. Pleijel, who was on the board of examiners.

Another solution which has been suggested is as follows: the daylight ratio in the winter months can be reduced to zero by using a high internal light intensity and working throughout the day with artificial lighting. The heat losses to the outside can then be reduced to a very low value by providing the windows with heat-insulating panels which completely shut out the daylight and prevent heat losses. These panels are, however, an additional expenditure which must be taken into account in an analysis.

COSTS OF ARTIFICIAL LIGHTING

The main items to be considered in calculating the lighting costs for a given building are shown in Fig. 3. The costs of installation, maintenance and operation can be determined by the usual methods. The cleaning costs should also be added. In many instances the cleaning of the lighting equipment is never carried out, with the result that the efficiency drops to one half or one quarter of its original value. On the other hand, the light is then converted into heat and thus contributes to the heating of the premises.

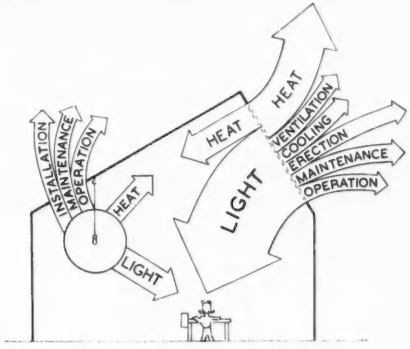


Fig. 3.

To calculate the costs of artificial lighting, we assume a certain value for the internal light intensity E_i and a mean value for the daylight ratio δ_m. The critical value for the external light intensity E_y is then determined by the formula

$$E_y = 100\, E_i/\delta_m.$$

Whenever the external light intensity drops below this level, the artificial lighting must be switched on to maintain the internal intensity at the required minimum level. Fig. 4 shows the variations of outdoor light intensity at the 60th degree of latitude. No artificial lighting is needed from April to August, when the outdoor light intensity is greater than 6,000 lux. By means of this diagram one can calculate the number of hours of artificial lighting per annum for a given value of E_i.

If this calculation is repeated for various outdoor light intensities E_y, a characteristic curve, such as that shown in Fig. 5, can be constructed. This shows immediately the number of hours of daylight and of artificial light obtainable for any given value of E_y, and, therefore, gives a direct indication of the cost of artificial lighting. Some advantage can be gained by switching on the lights gradually as daylight decreases, but a step-wise regulation of this kind is not always convenient or easy to install.

COSTS OF DAYLIGHT ILLUMINATION

To calculate the cost of day lighting we shall again refer to Fig. 3. The windows are large dissipators of heat during the cold season, and this represents an appreciable expenditure. However, for the purpose of this calculation, only the heat loss in excess of that normally attributable to the walls and ceilings per unit area should be considered, this being the "excess cost" of the windows.

The heating value of the light radiation coming in through the windows is to be taken as a positive contribution during the winter months. In the warm season, excessive radiation may make ventilating and cooling arrangements necessary and should, therefore, be avoided, preferably by a convenient orientation of the building. Painting over the skylights may be required during the summer, and this expenditure should be added to the operating costs of the windows.

Window cleaning figures as a prominent item in the expenditures. The daylight ratio which was assumed for the previous calculation of artificial lighting costs can only be maintained by having the windows cleaned at frequent intervals, unless windows of unnecessarily large dimensions are used. Inclined glass panes collect dirt much more readily than vertical panes, and the latter are generally more easily cleaned. Measurements in an industrial building indicated that, with soiled windows, the daylight ratio had dropped to 30 per cent of its original value, 25 per cent of the daylight being stopped by the glass and 45 per cent by the dirt deposited upon its surface. In another factory where the skylights had not been cleaned for 10 years, the daylight ratio had dropped to one-tenth of its value for clean windows. Thus, insufficient cleaning can result in considerable losses in the form of increased hours of artificial lighting.

The heat insulation of a window can be increased by providing it with an additional insulating pane, for instance, of "isoflex." The heat gained has to be weighed against the loss due to reduced transmission of daylight through the layer and the installation costs. The advantages of windows of various types and sizes should be compared. For instance, skylights are more

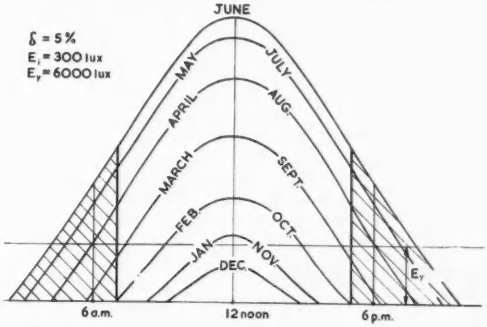


Fig. 4.

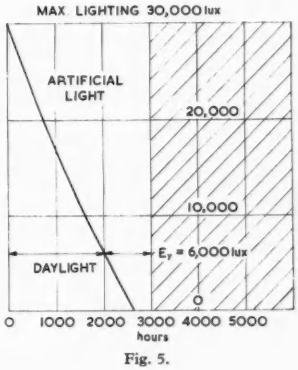


Fig. 5.

rapidly soiled than vertical windows, and the calculation should be made using the effective daylight ratio which can be obtained under normal operating conditions.

The colour of the light, both inside and outside the building, also has an appreciable effect on the daylight ratio. Thus, for instance, the colour of a roof which is provided with gable windows will partly determine the colour of the indoor light, and this also applies to the walls of buildings from which light is reflected before entering the windows.

TOTAL LIGHTING COSTS

The day-lighting costs include installation, maintenance and operating costs related to the windows. These comprise, among other items, the costs of additional heat losses, cleaning, and maintenance of correct colour of walls, etc. The total lighting costs are then obtained by adding to these expenditures the costs of the artificial lighting also expressed as functions of the daylight ratio. The minimum value of the resultant function is then determined. Kreuger arrives at the following expression for the optimum, i.e., the most economical, daylight ratio :—

$$\delta_m = E_i \sqrt{\frac{10\ k\ q\ \mu_n}{c\ P_n}}$$

where δ_m = most economical mean value for the daylight ratio, E_i = indoor light intensity, k = correction factor for artificial light regulation, q = cost of artificial lighting per lux-hour, μ_n = window utilisation factor (for n window cleanings per annum), c = slope (angular coefficient) of characteristic curve of Fig. 5, P_n = " excess cost " of windows in operation (proportional cost).

The correction factor k is equal to unity if all the lights are switched on simultaneously, and is less than unity for step-wise regulation. The proportional costs are those which vary in proportion with the size of the corresponding equipment. Thus, the installation costs do not vary with the indoor light intensity, whereas the current costs vary correspondingly.

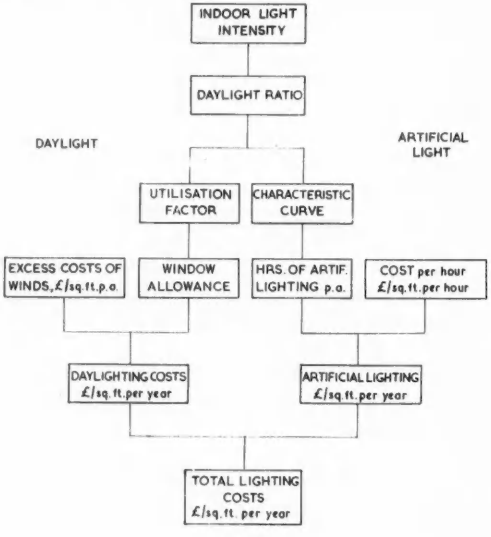


Fig. 6.

A schematic diagram of the method to be applied is shown in Fig. 6. A fixed value for E_i is first assumed. With a given value for δ_m we can then determine the hours of artificial lighting with the aid of the characteristic curve of Fig. 5. Knowing the cost per hour of the artificial light, we determine the contribution of the artificial lighting costs to the total costs. Regarding the day-lighting, we determine the utilisation factor for a given window allowance, i.e., for a given ratio of the window area to the floor area of the premises, with an assumed value for the daylight ratio. This figure is then multiplied by the excess cost, in per cent, of the windows, relative to the normal cost of walls and ceiling. In this manner, we obtain the contribution of day-lighting costs per square foot of floor area.

The method described above is based on the major factor, viz., the daylight ratio. Much depends, therefore, on the accuracy with which this ratio can be determined. Further research work is required in this direction. Kreuger, in his work, describes a purely mathematical method, and leaves out the geometrical methods generally used.

ILLUSTRATIVE EXAMPLE

Applying the above formulae to a factory building of the type shown in Fig. 7, we obtain for this an

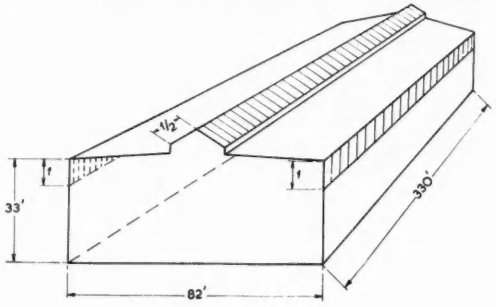


Fig. 7.

optimum value of approximately 3 per cent for δ_m, with an indoor light intensity of 300 lux. This gives a critical outdoor light intensity E_y of 10,000 lux. Referring to Fig. 4, we find that the daylight intensity is insufficient in November, December and January, and that there are only three hours of daylight of sufficient intensity in February and October. This makes one consider whether it would not be more economical to shut off the windows entirely by means of panels during these months, in order to reduce heat losses. However, the hours of artificial lighting are then increased so that the calculation would have to be repeated with this new condition, which, in turn, would give a new value for the optimum daylight ratio δ_m. Several trials are therefore necessary in order to arrive at the final result.

CONCLUDING REMARKS

Considering Fig. 5, it may be asked whether the night-like conditions obtained with heat-insulating window panels would not be the most economical solution. Taking the critical value for outdoor light intensity at 10,000 lux, there are 1,600 hours of daylight in the year, while windows dissipate heat to the exterior during 7,160 hours for no appreciable advantage.

In order to correlate calculations with actual values, it will be necessary to determine experimentally the daylight ratios and artificial light intensities now used under various conditions, with the aid of a lux-meter. A statistical survey of this kind, carried out over a period of several years, can give reliable data for the calculation of the optimum economic arrangements and dispositions, for instance, regarding window cleaning and lighting positions.

The Efficiency of Heat Engines

By W. TRAUPEL. (From *Teknisk Tidskrift*, Vol. 80, No. 46, December 16, 1950, pp. 1157-1164, 10 illustrations.)

This article describes a new method for the practical calculation of the thermal efficiency of heat machines operating with one or several working media. The evaluation of the entropy of reversible and irreversible processes is treated in detail. The working cycles of six different types of heat machines are analysed and compared, and the results are used to assess the possibilities of improvement of the different cycles.

(*Concluded from April issue*)

GENERAL EFFICIENCY FORMULAE

The above considerations are so general that the efficiency given by eq. (8) (see p. 118, April issue), also takes account of mechanical losses, boiler losses, etc. However, it should be borne in mind that each process is to be regarded as involving various media. For example, in a steam installation, the gaseous cycle in the boiler system should be dealt with as a separate partial process, and this also applies to the lubricating oil cycle, etc. As this is not suitable in practice, it will be more convenient to determine the thermal efficiency as the product of three partial efficiencies, viz. :

$$\eta_t = \eta_g \, \eta_l \, \eta_{tp} \quad .. \quad .. \quad (19)$$

where

η_g = efficiency of heat generation, i.e., efficiency of boiler and steam generating plant, efficiency of combustion in internal combustion engines, etc. (taking account of losses such as those due to incomplete combustion, which are not usually considered in thermodynamic theories, since, in principle, the unburnt fuel can be used again later) ;

η_l = effective transmission efficiency, which includes mechanical losses, losses due to auxiliary drives, electrical losses, etc. ;

η_{tp} = thermal process efficiency, that is, the efficiency of the process itself, which, for example, for a diesel engine with complete combustion, is equal to the indicated thermal efficiency.

When evaluating σ_v, σ_i, σ^*, τ' and τ'' it will be convenient to determine these for the thermal process only and use eq. (14) to obtain the thermal process efficiency η_{tp}.

The σ-terms have the disadvantage that their relative importance is very difficult to assess, because the expression $1 + \sigma_v + \sigma_i - \sigma^*$ appears as a factor which is subsequently subtracted from unity to determine the efficiency. This disadvantage can be overcome by substituting for η_{tp} the equivalent relation

$$\eta_{tp} = (1 - \xi_v - \xi_i + \xi^*)\,(T' - T'')/T'' \quad (20)$$

where $\xi_v = T''\,\sigma_v/\Delta T$, $\xi_i = T''\,\sigma_i/\Delta T$

$$\xi^* = T''\,\sigma^*/\Delta T, \quad \Delta T = T' - T'' \quad .. \quad (21)$$

The effect of the ξ-terms on efficiency is much more easy to follow. In fact it is possible to compare directly the ξ-values of different types of heat machines in order to obtain a more detailed appreciation of their relative merits. As, furthermore, each ξ is formed by adding the contributions of various partial processes, it is thus possible to assess at any stage of the calculation the effect of a loss in any portion of the cycle.

A further characterisation of a process is given by the temperature factor

$$\varphi = \frac{T' - T''}{T'} \, \frac{T_{max}}{T_{max} - T_0} \quad .. \quad (22)$$

which indicates how close a process approaches an ideal process (for instance, the Carnot process) with the temperature limits T_{max} and T_0.

The relation between φ, τ' and τ'' is given by

$$\varphi = (\tau'\,T_{max} - \tau''\,T_0) \Big/ [\tau'\,(T_{max} - T_0)] \quad (23)$$

and the thermal efficiency can therefore be written as

$$\eta_t = \eta_g \, \eta_l \, (1 - \xi_v - \xi_i + \xi^*)\, \varphi \, \eta_C \quad .. \quad (24)$$

where η_C is the Carnot efficiency.

APPLICATION TO VARIOUS HEAT MACHINES

Table I gives comparative values for the various quantities derived in the previous section for six different types of heat machines, viz. :

1. steam locomotive (Fig. 3) with 20 atm boiler pressure, 400° C maximum superheating temperature, feedwater preheating to 100° C ; the

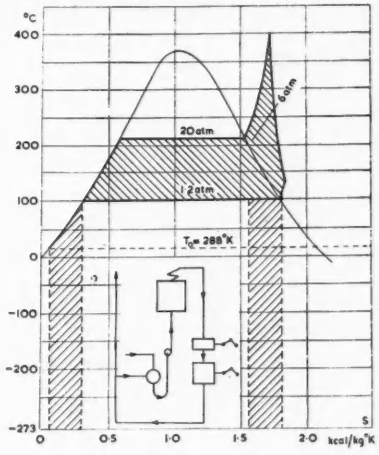


Fig. 3. **Steam locomotive cycle.**

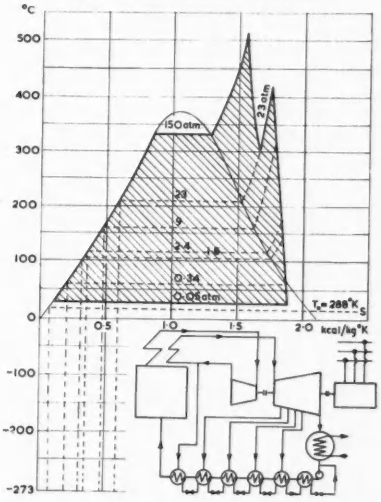


Fig. 4. **Cycle of high-pressure steam power plant.**

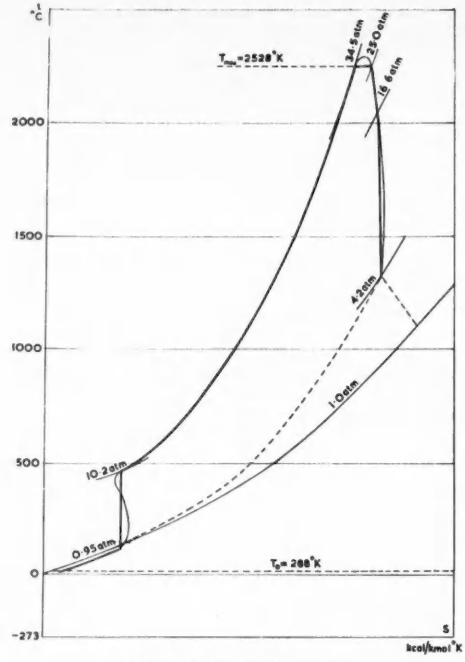


Fig. 5. **Petrol engine cycle.**

mechanical efficiency is calculated for the engine drive only and does not take account of rolling friction and coupling losses ;

2. high-pressure steam power plant (Fig. 4) with maximum pressure of 150 atm, superheat temperature 520° C, inter-stage superheating to 430° C at 23 atm, five bleed-offs for feedwater preheating, condenser vacuum 0·04 atm absolute ;
3. petrol engine (Fig. 5), four-stroke cycle, with a compression ratio of 5·4 : 1 and a 5 per cent lean mixture ;
4. diesel engine (Fig. 6), two-stroke cycle, with direct-driven scavenge pump ; compression ratio 13·9 : 1, scavenge air ratio 2 : 1, combustion air fuel ratio 2 : 1 ;
5. simple gas turbine (Fig. 7) with single-stage compression and single-stage expansion, without regenerator ; maximum pressure 4 atm absolute, maximum temperature 720° C ;
6. gas turbine power plant (Fig. 8) with three-stage compression and two-stages of intercooling, two-stage expansion, inter-stage combustion, and a regenerator ; maximum pressure 14 atm absolute, temperature 720° C.

The values given in Table I clearly show the advantages and disadvantages of each machine. It is remarkable that the Carnot efficiency is so favourable for the temperature limits at which these heat machines operate in practice, its lowest value being 57·2 per cent (for the steam locomotive) and its highest value 88·6 per cent (for the petrol engine).

The factor φ is a figure of merit which indicates the extent to which the available temperature range is utilised. The highest φ-value is obtained with the high-pressure steam installation, which has, however, a thermal efficiency considerably lower than that of the diesel engine. The gas turbine power plant has a thermal efficiency approximately equal to that of the diesel engine ; its heat supply is at a higher mean temperature than in the steam cycle, and its mean heat rejection temperature is somewhat lower.

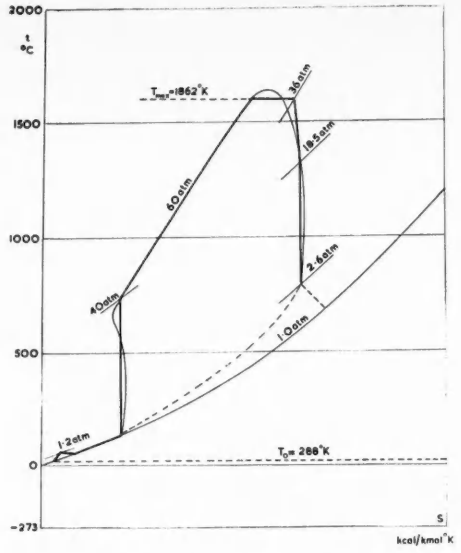


Fig. 6. **Diesel two-stroke engine cycle.**

The combustion engines reach less favourable φ-values, but the available temperature range is higher and has a preponderant effect on efficiency. Higher φ-values are the reason why the diesel engine has a higher efficiency than the petrol engine, and this also applies to the high-pressure steam plant as compared with the steam locomotive.

The quantity ξ_v represents the flow losses. It shows favourable values for the high-pressure steam plant and the combustion engines, and less favourable values for the gas turbine and the steam locomotive. The high ξ_v-value in the case of the steam locomotive is mainly attributable to the fact that it is very difficult to give a good streamline shape to the steam-regulating components, and with the high piston speeds generally obtained, considerable inlet losses are inevitable. It seems remarkable, however, that the gas turbine should have such high flow losses, although the latest results of aerodynamic research have been utilised to reduce them. The basic problem in this case is that large quantities of energy in relation to the useful power output flow from the turbines to the compressors, and

TABLE I.—EFFICIENCIES AND CHARACTERISTIC VALUES FOR VARIOUS TYPES OF HEAT MACHINES.

	Steam loco-motive	High-pressure steam plant	Petrol engine	Diesel engine	Simple gas turbine	Gas turbine plant
T_{max} (°K)	673	793	2,528	1,862	923	993
T_0 (°K)	288	288	288	288	288	288
η_C	0·572	0·637	0·886	0·845	0·688	0·710
T' (°K)	485	617	1,667	1,532	663	800
T'' (°K)	366	305	930	700	463	353
τ'	0·720	0·778	0·659	0·823	0·719	0·805
τ''	1·270	1·060	3·230	2·430	1·610	1·226
φ	0·429	0·793	0·499	0·643	0·438	0·787
ξ_v	0·284	0·186	0·144	0·179	0·375	0·268
ξ_i	0·060	0·049	0·170	0·0475	0·000	0·071
η_{tp}	0·161	0·387	0·303	0·420	0·189	0·369
η_g	0·775	0·900	0·950	1·000	1·000	1·000
η_t	0·900	0·950	0·820	0·910	0·960	0·960
η_t	0·112	0·331	0·236	0·382	0·181	0·354

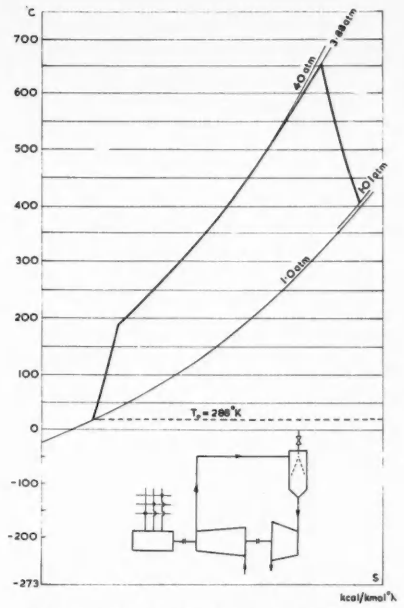


Fig. 7. **Cycle of a simple gas turbine plant.**

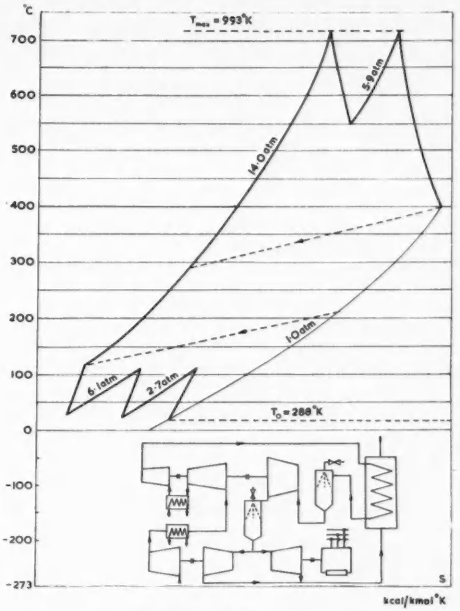


Fig. 8. **Cycle of a gas turbine power plant with a higher Carnot-cycle efficiency.**

even if the flow losses are small in relation to the overall output, they are considerable when compared with the nett output.

Values of ξ_i, which represent the reduction in overall efficiency due to heat exchange losses, are generally small. The low value of 0·049 for the high-pressure steam power plant shows that the preheating of the feedwater in five stages is very nearly an ideal thermodynamic process and that not much more could be gained by increasing the number of bleed-offs. For the gas turbine power plant, the value of 0·071 for ξ_i also shows that the overall efficiency will not be appreciably affected by improvements to the regenerators.

The high value for the petrol engine is due to the compression space, which is relatively large in this type of engine. The large quantity of hot gases remaining in this space after the exhaust stroke is mixed with the fresh aspirated air and gives a mixture with a high initial temperature. With two-stroke cycle diesel engines the loss is much lower, partly because the burnt gases are at a lower temperature and partly because the excess air used for scavenging makes it possible to achieve a good ejection of the residual gases. In the case of the simple gas turbine the value of ξ_i is zero, as a result of the intentional or unintentional interchanges of heat occurring in the process.

The efficiency of heat generation is represented by η_a. It corresponds to the boiler efficiency for steam locomotives and high-pressure steam power plants, and to the combustion efficiency in petrol engines. With petrol engines, combustion is never complete, because these engines operate with lean mixtures. However, complete combustion is possible with diesel engines and gas turbines. In aircraft gas turbines, losses due to incomplete combustion occur owing to the very high output of the combustion chamber.

The transmission efficiency η_l is generally good. Its value is lowest for petrol engines because as these operate on a four-stroke cycle they have a lower mechanical efficiency.

The highest value for thermal efficiency is reached by diesel engines, and $\eta_t = 0{\cdot}382$ is a fairly normal figure. The maximum value as yet obtained is 0·417.

It is of interest to compare the two heat machines which reach efficiencies nearest to that of the diesel engine, that is, the high-pressure steam power plant and the gas turbine plant. Both processes are about equally close to the ideal process, but the temperature limits are much more favourable in the case of the gas turbine, which appears to be able to cope with higher temperatures than those achievable in steam installations. Despite this, owing to its higher flow losses and imperfect internal heat exchange, the gas turbine has a somewhat lower thermal-process efficiency η_{tp} than the steam installation. Nevertheless, the overall efficiency of the gas turbine power plant is slightly higher than that of the steam power plant because its heat generating efficiency, with internal combustion, is equal to unity, whereas $\eta_a = 0{\cdot}9$ for the steam installation. However, the gas-turbine plant and the high-pressure steam power plant are complementary to one another, since the latter in its most highly developed form is used only for high power outputs of the order of 50,000 kilowatts or higher, whereas the former is used with advantage in the 1,000-30,000 kilowatt range.

The values given in Table I also indicate in which directions it would be possible to improve the various heat machines.

1. Steam locomotive : The first obvious step is to try to improve its φ-value, by reaching higher pressures and expanding down to negative pressures, with the aid of a condenser. This has already been tried, but so far no substantial improvement in economy has been arrived at. Another way is to try to reduce flow losses and to obtain better boiler efficiencies. For instance, with $\xi_v = 0{\cdot}2$ and $\eta_a = 0{\cdot}85$ (instead of 0·284 and 0·775, respectively), the value of η_t would be 0·15 (instead of 0·11).
2. High-pressure steam power plant : All the terms have such favourable values that little can be gained by fundamental improvements, and no new steam-generating process will show a substantially higher efficiency. A certain improvement can be obtained only by increasing the superheating temperature.
3. Combustion engines : Improvements can be

obtained by increasing the temperature ratio φ and by improving design features which affect the working cycle. If a diesel engine could be built with a φ-value of 0·8 (instead of 0·643), its thermal efficiency would reach a value $\eta_t = 48$ per cent.

4. Gas turbines : A much more favourable cycle is not possible within the given temperature limits, since φ is already very high. The value of ξ_i indicates that no great gain can be expected from improvements in the regenerators. However, ξ_v shows that there is much to be gained by improving the flow conditions. It is doubtful whether the efficiency of turbo-machines can be improved to any extent, except by increasing the maximum temperature. This applies not only to open-cycle gas turbines but also to other types of gas turbines operating in closed or semi-closed cycles. The advantages gained by closed or semi-closed cycle processes are not actually of a thermodynamic nature but rather the results of improvements in construction and operation (smaller dimensions for the various components). With closed-cycle gas turbines, the advantages of internal combustion are lost, so that the working process itself must be of a higher quality than for the open or semi-closed cycle in order to obtain the same overall efficiency. The primary advantage of the closed-cycle gas turbine is that it can be made to operate on coal or other solid fuels.

Fig. 9 gives an approximate outline of the ranges of power output over which the various heat machines mentioned above now operate. For very small power outputs, apart from certain exceptions, the petrol engine is outstanding. Similarly, for very large power outputs, the type of machine is also determined, since

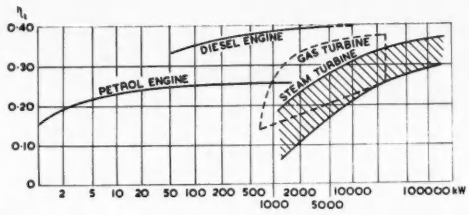


Fig. 9. **Range of power outputs and thermal efficiency of various types of heat machines.**

only steam power plants come into consideration. In between is a power range within which various types of heat machines can be employed. In this connection, it is justifiable to forecast that increased use will be made of turbo-machines. The gas turbine plant thus gains considerable importance, since in the intermediate range of power outputs its efficiency is somewhat more favourable than that of the steam power plant. Furthermore, combinations of gas and steam turbines will be a factor to be reckoned with, since they can combine a number of advantages of both systems as regards economy and operating efficiency.

BIBLIOGRAPHY.

CHAPELON : High-speed locomotives. "Revue Gén. Chemins de Fer," Vol. 54, 1935, p. 110.

EICHELBERG : 5500-hp two-stroke cycle diesel engine for marine propulsion. "Dieselmaschinen," Vol. 6, Berlin, 1936.

NUSSELT : Entropy increases in gas machines caused by irreversible combustion. "Z. ges. Turbinen-Wesens," Vol. 14, 1917.

PLANCK : Thermodynamics. 7th edn., Berlin-Leipzig, 1922.

STODOLA : Steam and gas turbines. 6th edn., Berlin, 1924.

AUSTRIA

The Physical Characteristics of D.C. Generators

By R. BRÜDERLINK and K. GEIGENMÜLLER.

(From *Elektrotechnik und Maschinenbau*, Vol. 67, No. 11, November, 1950, pp. 332-341, 16 illustrations.)

D.C. generators used for arc welding must possess special static and dynamic characteristics. These can be obtained by various means. Design features have been developed which enable machines to fulfil both types of requirements.

(*Concluded from April issue*)

THE physical significance of these equations (see p. 128, April issue), will now be determined by considering various conditions.

(a) *No yoke saturation, magnetic potential in the yoke neglected* (so that $\Lambda_j = \infty$), *no SC winding*: Equations (7) become

$$\Phi_a = \Lambda_a \Theta_r, \Phi_s = \Lambda_s (\Theta_r + \Theta_s), \Phi_j = \Lambda_s (\Theta_r + \Theta_s) + \Lambda_a \Theta_r,$$
$$\Phi_{a0} = \Lambda_a \Theta_{r0}, \Phi_{s0} = \Lambda_s \Theta_{r0}, \Phi_{j0} = (\Lambda_s + \Lambda_a) \Theta_{r0} \quad \ldots (8)$$

The expressions for Φ_a and Φ_{a0} indicate that a suitable static characteristic is obtained only if the exciting ampere-turns can be made to decrease with the load current, by using an appropriate circuit. In such a case, with a suitable value for the stray pole ampere-turns, the yoke flux, for instance, can remain constant. When changing over from short-circuit to open circuit, the exciting current then immediately reaches its no-load value, since the corresponding flux is already linked up with the exciting winding. On short-circuiting, a current pulse need not occur, since the exciting current can instantaneously reach its short-circuit value, with no flux linkage variation.

(b) *No yoke saturation, but a SC winding*: In this case, we have

$$\Phi_a = \Lambda_a (\Theta_r - \Theta_g), \Phi_s = \Lambda_s (\Theta_r + \Theta_s), \Phi_j = \Lambda_s (\Theta_r + \Theta_s) + \Lambda_a (\Theta_r - \Theta_g), \Phi_{a0} = V_a \Theta_r, \Phi_{s0} = V_s \Theta_r, \Phi_{j0} = (\Lambda_s + \Lambda_a) \Theta_r \quad \ldots (9)$$

A suitable falling static characteristic is obtainable even with a constant value for Θ_r. The system can be adjusted so that $\Lambda_s \Theta_s - \Lambda_a \Theta_g = 0$. The flux Φ_j remains constant. There is no current pulse, because, as the current increases, the armature flux Φ_a and the e.m.f. drop to a value corresponding to the magnetising ampere-turns $\Theta_r - \Theta_g$. Similarly, on opening the circuit, the full no-load voltage is reached suddenly.

(c) *Yoke saturation, but no SC winding*: Putting $\Theta_g = 0$ in eq. (7) we obtain

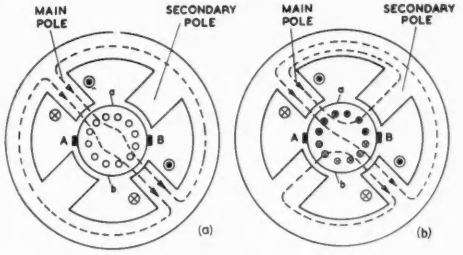
$$\Phi_a = \Lambda_a (\Lambda_j \Theta_r - \Lambda_s \Theta_s)/\Sigma\Lambda, \Phi_s = \Lambda_s [\Lambda_j \Theta_r + (\Lambda_j + \Lambda_a) \Theta_s]/\Sigma\Lambda, \Phi_j = \Lambda_j [(\Lambda_s + \Lambda_a) \Theta_r + \Lambda_s \Theta_s]/\Sigma\Lambda,$$
$$\Phi_{a0} = \Lambda_a \Lambda_j \Theta_r/\Sigma\Lambda, \Phi_{s0} = \Lambda_s \Lambda_j \Theta_r/\Sigma\Lambda, \Phi_{j0} = \Lambda_j (\Lambda_s + \Lambda_a) \Theta_r/\Sigma\Lambda \quad \ldots (10)$$

The effect of the stray poles contributes to the production of a falling static characteristic. The tendency of the yoke flux to increase is limited by the yoke saturation (Λ_j becoming smaller). Dynamically, no significant changes occur.

(d) *Yoke saturation and SC winding*: Equations (7) and (7a) apply. The static characteristic drops, of course, more steeply than in the previous case. A clearer appreciation is obtained by assuming that Θ_r is constant and that, with suitable adjustment, $\Lambda_s \Theta_s - \Lambda_a \Theta_g = 0$. In this case, the yoke flux remains at its no-load value. There is no short-circuit pulse and no voltage peak in reaching the full no-load voltage.

(c) *Yoke saturation and SC winding but no stray pole excitation* ($\Theta_s = 0$: Equations (7) show that the stray poles are still effective to a certain extent and affect both the static and the dynamic characteristic in the right manner.

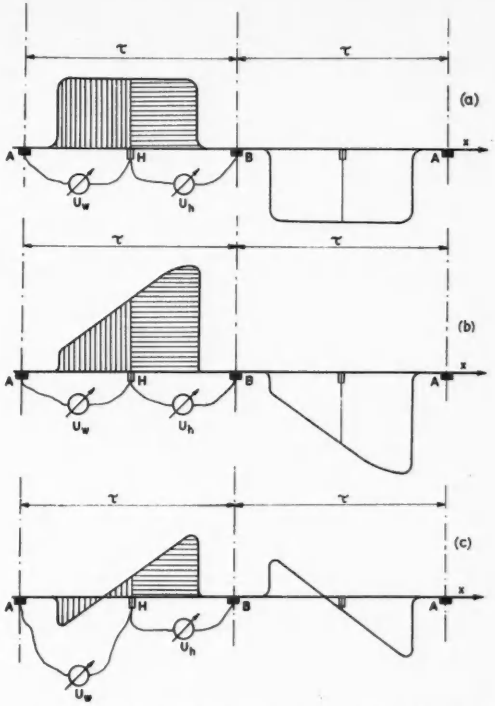
8. *Machine with flux controlled by auxiliary poles*: This arrangement, shown in Figs. 11a and 11b, was originally developed in America, and is somewhat similar to that of the stray pole machine. Each pole is split into two poles, viz., a main pole, carrying the exciting winding, and an auxiliary pole, which may or may not be provided with a series winding which can be switched in either direction (i.e., assisting or in opposition). Fig. 11a shows the flux pattern for no-load. The exciting flux below one of the main poles passes into the armature and leaves it through the main pole which is oppositely situated to it. The no-load voltage is induced in the area covered by these poles. The flux in the air-gap of the auxiliary poles is zero for no-load, and there is no induced voltage in this area.



Figs. 11a and b. **Generator provided with auxiliary poles.**

Under load conditions, the flux pattern is as shown in Fig. 11b. Let it first be assumed that the auxiliary poles have no windings (or that no current flows through these windings). An opposing flux passes through the auxiliary poles from the zones *Aa* and *Bb* of the armature. An additional flux of the same magnitude would be excited through the main poles, with the effect that the induced voltage would be zero, but is suppressed as a result of the higher saturation of the main poles, which can be made as high as necessary, since these poles have a smaller cross-section than the auxiliary poles. Thus, with this machine, the required effect is obtained by saturation of the iron. By making use of the armature reaction, the machine obtains a falling static characteristic without reducing the flux linkage of the exciting winding and the main poles, which remains constant even if the exciting current decreases under increasing load. With the simple system described, the static characteristic and, therefore, the welding current can only be altered by varying the no-load voltage from the exciter, and this limits somewhat the range of currents available for welding. However, a wider range can be obtained by means of the series windings on the auxiliary poles. If the series winding is so connected that it will assist the flux excited by the armature, the static characteristic will have a steeper drop and the welding current will be correspondingly reduced. When the winding is connected so as to oppose the armature flux, the welding current will be higher. The series winding does not affect the dynamic properties of the machine.

EXCITING WINDING WITH AUXILIARY BRUSHES: In the previous considerations it was generally assumed that the exciting winding was supplied with a constant voltage, obtained, for instance, by means of a dry rectifier. Various machines incorporating this feature are now on the market. However, there is another possible solution which makes the rectifier unnecessary and which, for various other reasons, seems particularly suitable for welding generators. This consists in



Figs. 12a, b and c. **Effect of an auxiliary brush: "Hard" voltage U_h and "soft" voltage U_w.**

using an auxiliary brush, situated approximately halfway between the two main brushes. The effect of this brush is illustrated in Figs. 12a, b and c, for open-circuit, load and short-circuit conditions, respectively. The auxiliary brush H splits the voltage between the main brushes A and B into two voltages U_h and U_w. U_h is proportional to the vertically-sectioned area, and U_w to the horizontally-sectioned area of the main flux. Under no-load, both these voltages are equal, the auxiliary brush being situated at the centre position. Under load (Fig. 12b), U_w decreases while U_h tends to increase, but its rise is much less marked than the drop of U_w, owing to saturation effects. The voltages U_h and U_w will be called the "hard" voltage and "soft" voltage, respectively. Under short-circuit conditions, U_w can even become negative, whereas U_h always has an appreciable positive value. Therefore, by providing a generator with combined excitation, as shown, for instance, in Fig. 13, and suitably adjusting the two component voltages U_h and U_w by means of the field regulators R_w and R_h, it is easy to modify the static characteristic to suit any requirement within wide

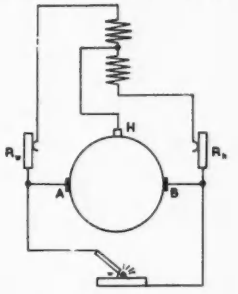


Fig. 13. **Combination of "hard" and "soft" voltages to obtain various static characteristics.**

limits. Machines of this type have already been built as welding machines, but despite their excellent static

(*Concluded on page* 170)

Journal Bearings with Hydrodynamic Lubrication

By W. FROESSEL. (From *Stahl und Eisen*, Vol. 71, No. 3, February 1, 1951, pp. 125-128, 8 illustrations.)

Axial oil grooves cut into the bearing surface of a journal bearing subdivide the bearing surface and make it possible to obtain several independent, wedge-shaped, oil films. Purely hydrodynamic lubrication can thus be obtained in many cases.

IN hydro-dynamic lubrication, the oil film not only serves to minimise friction but is also capable of carrying the entire bearing load. The shaft floats on the oil film and wear hardly takes place at all. Certain conditions must exist if hydrodynamic lubrication is to be obtained; where these conditions are not fulfilled, boundary, or mixed boundary and hydrodynamic, lubrication will result in contact between rubbing metals and consequent wear. One essential condition for hydrodynamic lubrication is the existence of a wedge-shaped oil film narrowing in the direction of rotation of the shaft. The shaft acts as an oil pump entraining the liquid which adheres to the moving shaft surface on one side and to the fixed bearing surface on the other. If the oil is thus pressed through a narrowing gap and the same quantity of oil flows through each section along the gap, the resulting compression of the streamlines in the narrowing portion must result in a build-up of fluid pressure which, if high enough, will resist the forces between shaft and bearing without rupture of the oil film. A parallel gap does not develop this fluid pressure and the oil film in it will usually be unable to carry the imposed load. Fig. 1, for instance, shows the influence of a strong wedge effect on the velocity distribution of the oil in the gap. This distribution may easily be explained by theoretically superposing two types of oil flow: (a) the forward flow caused by the pumping action of the moving shaft and (b) the pressure flow generated by compression of streamlines and tending to squeeze the oil out of the gap in any direction. The pressure flow opposes and may exceed the forward flow at certain points of the narrowing portion of the gap (Fig. 1, left) so that the oil actually flows against the direction of shaft motion at these points. The ensuing oil pressure distribution along the length of the gap is shown in Fig. 2 for various wedge angles. It is seen that the essential rise in oil pressure is limited to a region of about 30 degrees of the bearing circumference near the narrowest section of the bearing circumference; this small segment of the bearing surface thus carries practically the entire bearing load.

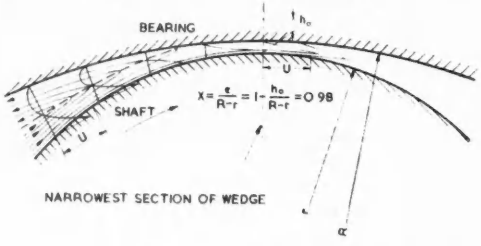


Fig. 1. **Velocity distribution of oil flow in eccentric bearing gap.**

High oil pressures are obtained in the gap if the amount of oil drawn into the gap is large; hence the gap should be rather wide. On the other hand, the resistance against outflow of oil must also be high, which indicates that the gap should be narrow. A compromise between these conflicting conditions must be found and the optimum value of gap width thus determined from the well-known Reynolds-Sommerfeld lubrication theory. In ordinary journal bearings with, say, 0·004 in. play, the theoretically correct wedge shape would require a dimensional accuracy greater than can

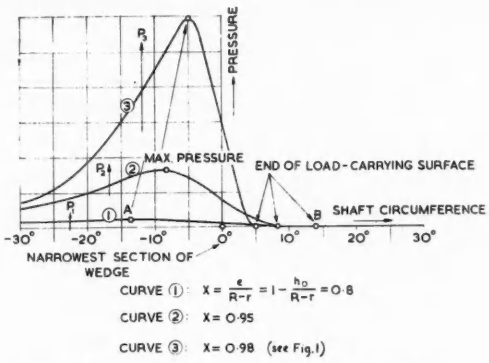


Fig. 2. **Pressure distribution over the arc length of the gap.**

be obtained with normal manufacturing and fitting tolerances or with unavoidable distortions caused by internal stresses and unequal heating. The very small wedge effect due to ordinary bearing play may thus be reduced and disappear, or be enlarged, so that apparently identical bearings may show very different friction and wear characteristics. In order to minimise the influence of these accidental distortions in the wedge shape of the oil gap, it would be necessary to choose a wedge shape 5 to 10 times steeper than that of an ordinary journal bearing. The resulting required total bearing play (about 1·5 per cent of the bearing diameter) would then not be permissible in practice. The only practical solution is a separation of gap eccentricity and bearing play. Since a sufficient oil pressure rise can be obtained over only 30 degrees of bearing circumference, it is possible to arrange several such bearing segments on the bearing circumference with separate independent oil films in each segment (Fig. 3). Between two adjacent segments, i.e., in a zone out of contact with the shaft, large axial oil grooves may provide for sufficient inflow of oil. Three bearing segments in small, and four segments in larger, bearings have been found most advantageous. Each segmental bearing surface then produces a force, and the unloaded shaft is thus centred accurately. Under load, the gap width on the loaded side decreases and the force exerted by the segment on this side increases, while on the unloaded side, the gap width increases and the force is reduced. The external load is therefore balanced by the resultant oil force.

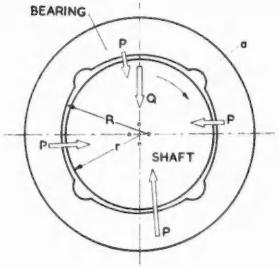


Fig. 3. **Schematic arrangement of journal bearing with several load-carrying segments.**

The characteristics of a bearing of this type are :

(1) Several independent lubricating oil films distributed over the bearing circumference produce the required support reactions.
(2) No metallic contact between shaft and bearing, hence infinitesimal wear.
(3) Large load carrying capacity for continuous running, and permissible bearing pressure of 1150 to 2850 psi.
(4) Intermittent and shock loading may be higher still, but allowable values depend on the duration of the applied load and the viscosity of the lubricant which may have to resist an appreciable static pressure.
(5) Small coefficient of friction of about 0·01 to 0·005. Values of 0·001 can be reached with very high surface smoothness and utilisation of the full load carrying capacity.
(6) Bearings are suitable for very low to very high speeds. Tests were carried out with 0·00015 to 100 fps circumferential speed at 2150 psi bearing pressure ; higher speeds are admissible.
(7) Freedom from noise and good damping.
(8) Smallest bearing plays are possible without impairing lubrication. Bearings with a play of 0·01 per cent of the shaft diameter were tested (normal play in journal bearings is 0·1 to 0·2 per cent). The bearings are thus especially suitable for machine tools.
(9) Any lubricant of suitable viscosity, boiling point, and non-corrosive qualities may be used. Oil bath or circulating oil lubrication may be arranged, according to bearing, friction, and heat conditions. Forced lubrication is not required ; it is sufficient if the oil grooves are filled with oil and the oil circulation disperses the frictional heat.
(10) The carrying capacity may be calculated from

$$P = \eta v c$$

where P = load carrying capacity in lbs, η = viscosity in lb sec/sq ft, v = circumferential speed of shaft in fps, and c = calculated bearing coefficient depending on the shape of the oil gap. Changes in viscosity with temperature must therefore be considered for the design of high-speed bearings. Low-speed high-pressure bearings demand oils of very high viscosity.

Segmental bearings have proved successful where ordinary journal bearings have failed, and they are specially suitable for modern high-speed high-performance machinery, e.g., gas turbines, compressors, centrifuges, etc.

FRANCE

The Study of Sintering Phenomena by means of Continuous Contraction Measurements

By S. Tacvorian and M. Lévêcque. (From *La Recherche Aéronautique*, No. 19, January-February, 1951, pp. 49-58, 20 illustrations.)

Continuous measurement of the linear contraction of a test bar during sintering in an H.F. furnace permits observation of the physico-chemical changes in the material as sintering progresses. A suitable instrument is described and examples of observations on ceramic materials are given.

The overall shrinkage of a sintered specimen is known to characterise, in some manner, the sintering process under given conditions for a given material. The most favourable temperature and the amount of shrinkage to be expected in practice can thus be found. However, shrinkage is not necessarily linear, irreversible, or uniquely connected with sintering temperature, but more probably progresses in discontinuous steps depending on the changes in the material during sintering. Continuous measurements of the linear contraction of a test bar will therefore permit detection of these changes and the investigation in a general manner of sintering or similar chemical phenomena.

Description of instrument. (Fig. 1)

A supporting tube, 0·63 in. external diameter, 0·08 in. wall thickness, 12⅝ in. length, made of sintered alumina and sufficiently strong for the temperature range considered (1000 to 1750° C), is secured at one end in a detachable water-cooled flange and inserted horizontally in an H. F. furnace with air, or air and oxygen, convection. The upper half of the tube is cut away over a length of 3½ in., starting 1 $\frac{9}{16}$ in. from the free end of the tube. The test bar is placed in this open portion, one end resting against a fixed insert in the short free end of the supporting tube. A movable alumina cylinder held in spring contact with the other end of the specimen transmits any change in specimen length to the outside of the furnace by means of an alumina rod guided in frictionless packing glands. The alumina rod, in turn, actuates a metal rod, and a pivoted lever then transmits the motion, 7·5 times amplified, to a sliding carriage mounted on ball bearings and carrying a stylus. Lever and carriage are pressed against the transmission rods by means of a dead weight of about ¼ oz. The movement is recorded on a uniformly rotating drum of 2⅝ in. diameter, making one complete revolution every six hours.

Operation and evaluation of recordings

The test pieces are of rectangular cross-section (0·24 in. by 0·20 in.), 2·40 in. length, and compressed from powdered material in a metal mould under a pressure of 10 tsi which is reached in one minute, maintained for a further minute, and removed slowly. Recording measurements are taken as from the commencement of heating, and the pre-arranged speed of heating should, in general, not exceed 200 to 400° C per hour. Screens inside the furnace support the alumina tube and mark the limits of the zone of constant temperature, which is measured at short intervals by Pt — Pt/Rh thermocouples or, when above 1000° C, by an optical pyrometer directed onto the specimen surface.

In the simplest case, the recorded contraction-time curve, first a vertical line denoting zero contraction, bends at the commencement of sintering into a steeply inclined line marking rapid contraction, and returns to the vertical direction when sintering is finished. The most characteristic points are the temperature at the commencement of sintering, the inclination of the line, i.e., speed of contraction, during sintering, and the magnitude of overall contraction. If physico-chemical changes intervene, the diagram is more complex and indicates, e.g., gaseous discharges, allotropic and molecular changes, etc. Before evaluation, the recordings are transformed into graphs giving the contraction as a function of the temperature at which the contraction takes place. From the frequent temperature readings a temperature-time curve is

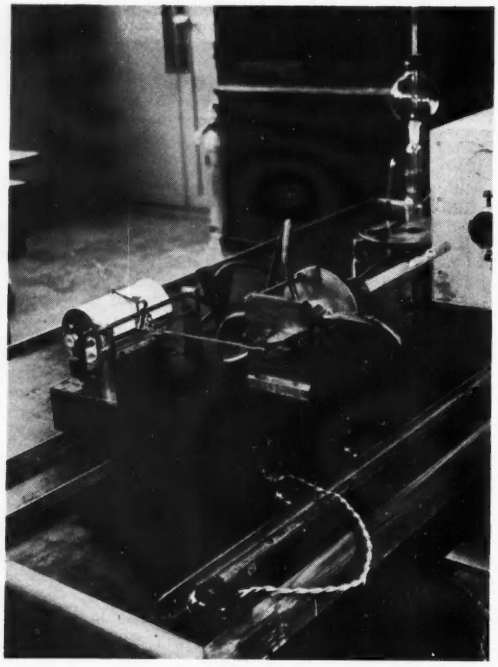


Fig. 1

drawn (e.g., Fig. 2 left). This will also provide a check on the pre-arranged heating schedule. Since the speed of rotation of the recording drum is known, the temperature corresponding to any point of the recorded diagram may be noted. As an additional check, the temperatures of important points may be marked while the test is in progress. The contraction-temperature curve can then be plotted as shown (e.g., by Fig. 2, right), where the scale of the recorded curve has been doubled ; the plotted contractions thus represent 15 times the actual contractions.

ACCURACY OF THE METHOD

(a) *Temperature-time curve.* Check tests showed that the zone of constant temperature practically radiates as a black body without any further precautions. If the specimen is heated at a rate of 200 to 400° C per hour, careful readings can be taken to within 5° C, the limit of precision of a normal pyrometer, without any noticeable change of temperature during the time of

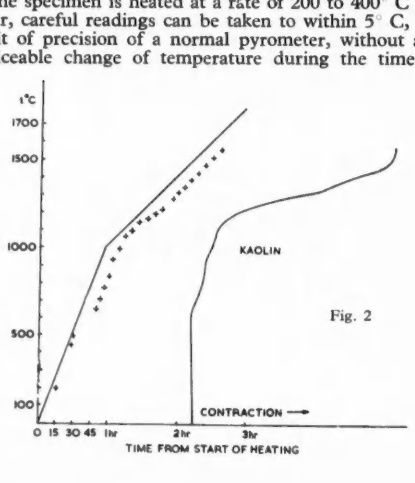


Fig. 2

reading. The reading itself takes about 15 seconds, so that temperature and time of reading are determined to a satisfactory degree of accuracy.

(b) *Temperature-contraction curve.* The contraction-time record can be read to within $^1/_{64}$ in. This corresponds to 0·002 in. actual contraction of the specimen and may be accepted as the limit of accuracy, since the precision of leverage and transmission rods falls well within this limit. The overall contraction is about 15 to 20 per cent of the specimen length of 2·40 in., so that this accuracy represents about 0·6 per cent of the overall contraction. $^1/_{64}$ in. of the drum circumference represents a time of 40 sec or, with an hourly heating rate of 200 to 400° C, a temperature increase of $2\frac{1}{4}$ to $4\frac{1}{2}$° C. Any error from the reading of the diagram will thus remain below 5° C, i.e., within the accuracy of pyrometer readings.

(c) *Error due to heat expansion.* The supporting tube and transmission rod of alumina form a self-compensating system for heat expansion ; only the length occupied by the test specimen cannot be fully compensated. However, even if the coefficient of linear expansion of the test material, e.g., of magnesia with $\alpha = 120 \times 10^{-7}$ in. per in. per °C, is very different from that of the alumina tube (80×10^{-7} in. per in. per °C), the differential expansion at 1750° C would only be $(120 - 80) \times 10^{-7} \times 1750 \times 2{\cdot}4 = 0{\cdot}017$ in. or $\frac{1}{8}$ in. on the recorded diagram. The trace would gradually be displaced up to this amount, but correction could easily be made by calculation or determination of the final contraction line after cooling. With most materials, the difference is very much smaller, if at all noticeable.

RESULTS OBTAINED FROM CONTRACTION MEASUREMENTS.

The following examples are taken at random and only meant to illustrate the efficacy of the method. For convenience, the specimens were heated to 1000° C in one hour, then by 400° C per hour.

(a) *Kaolin group*

In view of the plasticity of Kaolin clays, the specimens were pre-pressed at 5000 psi only. Specially *purified kaolin* (Fig. 2) shows a first contraction (start of sintering) at 600° C, when water is eliminated. The curve then has a constant slope up to 750° C, where the total contraction is about 1 per cent. The curve steepens again, and a second point of inflexion at 910° C denotes the start of decomposition of kaolin with segregation of silica. This change is again accompanied by a contraction of about 1 per cent. Between 1100 and 1450° C the main contraction takes place, and above 1450° C, the sintering process is nearly finished, only infinitesimal further contraction being possible. The overall contraction is 14 per cent. Owing to the very high heating rate (Fig. 2, right) the characteristic points are probably displaced ; a systematic investigation would require much lower heating rates.

Sèvres porcelain clays exhibit similar characteristic phenomena. *Synthetic mullite*, i.e., kaolin mixed intimately with very fine alumina powder (Fig. 3), shows the same phenomena at first, but sintering begins at 1100° C, is much slower, and is arrested at 1500° C with a total contraction of 7·5 per cent. This may be due to a reaction between alumina and the silica segregated from kaolin. Sintering re-commences above 1600° C and contraction between 1600 and 1700° C is very rapid, ending at an overall value of 20 per cent Products rich in mullite should therefore be sintered above 1600° C, a fact borne out by the increase in tensile strength obtained by such treatment.

(b) *Alumina group*

The sintering action of *pure alumina*, 99·8% Al_2O_3, (Fig. 4) starts at 1000° C, hence the advantage of presintering and shaping at 1200 to 1300° C. Above

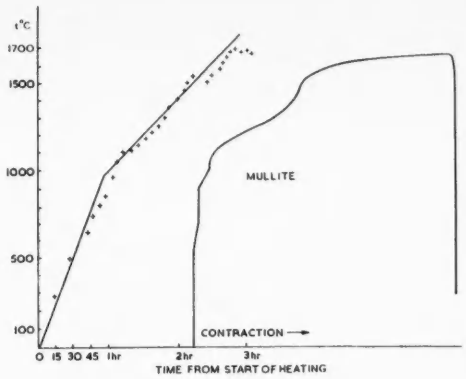


Fig. 3

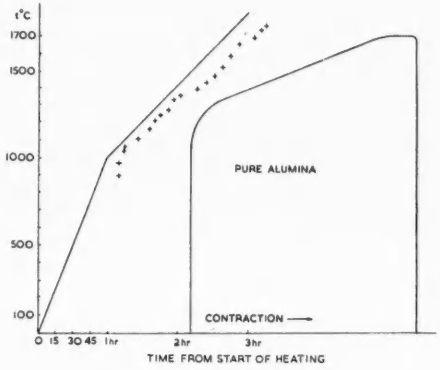


Fig. 4

1300° C, a constant slow sintering contraction is evident. The test was stopped at 1700° C with an overall contraction of 17·5 per cent. It is known that traces of additional elements largely influence the properties and microstructure of the sintered alumina product, and contraction measurements reveal the characteristic changes that take place during sintering. Additions of 1 per cent or more Cr_2O_3 increase the temperature at the commencement of sintering, and sintering finishes at about 1700° C. These changes may be due to the volatility of Cr_2O_3 at high temperatures. Additions of MgO or ZnO, however, do not essentially affect the sintering process. *Talc* is often used to catalyse the sintering action of alumina, but contraction measurements reveal that only the magnitude of the overall contraction is increased.

An addition of only 0·5 per cent Mg-fluoride is know to improve appreciably the qualities of sintered alumina and to refine its crystalline structure. The diagram (Fig. 5) shows a slight contraction at the commencement of sintering at about 1200° C, but then shows a rapid extension to the original specimen length at 1300° C. Exceptionally rapid sintering finally takes place from 1600° C (4·3 per cent contraction) to 1750° C, ending with an overall contraction of 19 per cent. Additions of 1 per cent CaF_2 also lead to accelerated sintering at higher temperatures, so that the beneficial influence must be attributed to fluorine rather than Mg or Ca. The sintering action may be explained as follows : After a slight initial contraction of the mass, the MgF_2 melts at 1270° C, covers and wets the surfaces of the alumina grains, and hydrolyses in the presence of water vapours in the furnace atmosphere. The increase in gaseous volume prevents the alumina grains from joining

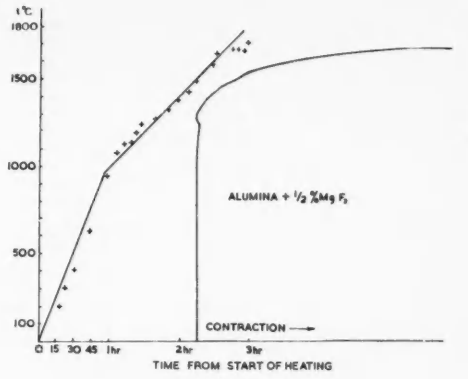


Fig. 5

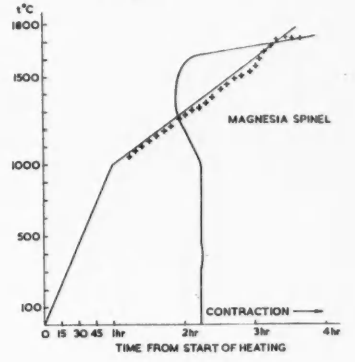


Fig. 6

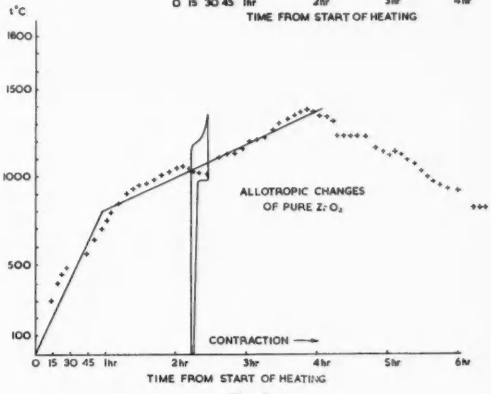


Fig. 7

and sintering, and restricts their growth. Above 1600° C, the fluorine has already evaporated and sintering takes place quickly without any appreciable grain growth. The action of CaF_2 is less pronounced because of its higher melting point of 1360° C.

(c) *Diverse materials*

The curve of *magnesia spinel* obtained from a stoichiometric mixture of freshly calcinated MgO and Al_2O_3 (Fig. 6) shows an expansion from 970 to 1300° C, confirmation of the fact that the unsintered spinel is lighter than the stoichiometric mixture. The spinel then sinters rapidly above 1600° C. A small irregularity showing at 300 to 500° C is due to decomposition of Mg-hydrocarbonate formed during preparation of the sample. The allotropic change of *zirconium oxide* is well shown by Fig. 7. The material was exceptionally

pure and fine-grained, the specimen being pre-sintered at 1600° C, then cooled in ten hours. The test was conducted slowly at temperatures above 800 C. The allotropic change on heating starts at 1150° C and finishes at 1300° C with a contraction of 1·2 per cent, whilst during cooling it occurs suddenly at the lower temperature of 990° C. Various interruptions of the heating rate, as shown by the dotted temperature-time curve, do not affect the transformation points.

CONCLUSIONS

Contractions of solid materials undergoing transformation changes can be detected by the instrument described if the linear variations produced are greater than 0·1 per cent. In one continuous experiment, the instrument supplies information about sintering temperatures, about the progress of contraction or expansion, and about overall contraction, thus elucidating theoretical and practical aspects of sintering phenomena. Tests on alumina, with additions of MgF_2, for instance, prove that a fine-grained sintered product is obtained not by slow sintering at low temperatures but, paradoxically, only by preventing the tendency to sintering at low temperatures.

ITALY

An Aero-Electric Pilot Plant of Medium Power

By R. VEZZANI. (From *L'Elettrotecnica*, Vol. 37, No. 9, September, 1950, pp. 398-419, 30 illustrations.)

This article describes a basically new type of air-motor which is totally enclosed in a Venturi tube arrangement. The aerodynamic problems related to this system are dealt with in detail and the possibilities of the new design as regards power output, efficiency and economy are investigated.

THE utilisation of wind energy has previously met with insurmountable difficulties from the point of view of aerodynamics. These were mainly due to the wrong direction given from the very outset to the design of the windmill and its supporting structure. The aims were (1) to endeavour to cover the maximum possible area across the direction of the air current, and (2) to try to situate the rotor as high as possible above the ground in order to utilise higher wind velocities and more stable wind conditions.

The above requirements resulted in the use of (1) large rotor vanes and extremely complicated rotor mechanisms, and (2) extensive metallic structures with a tendency to develop severe vibrations under strong wind conditions. The most delicate parts of the windmill and the electric system were left exposed to violent dynamic loads and stresses.

Once the deficiencies of the present aero-electric designs are realised, it becomes clear why wind energy, which, after solar energy, is the largest natural source of power, has not been adequately harnessed. The basic features of an efficient wind energy project can therefore be outlined as follows:—

(i) in view of the diffuse nature of the wind forces, the slow-speed orientatable windmill designs should be replaced by high-speed air-motors, protected and fixed in space, and directly coupled to the electric generator;
(ii) the air ducts should be fixed in space and solidly built on the ground, so as to result in a stable, sturdy and economical design;
(iii) the orientatable parts of the aero-electric plant should be reduced to a minimum;
(iv) to increase the efficiency of the conversion of wind energy into electrical energy, the entire air-motor can be placed in a tubular system similar to a Venturi tube, with the air-motor in the narrowest cross-section, the rear portion of the tubing being left open so as to obtain a depression, with the result that the wind velocity is increased to 3 times its value in the converging inlet portion of the tube.

The use of two or more co-axial Venturi type tubes with draught increasing devices at the diffuser exit increases the depression in the throat cross-section and raises the velocity at the tube inlet to $1\frac{1}{2}$ times the value of the wind velocity. The efficiency of the air-motor is increased by the totally enclosed arrangement. The air-motor operates much in the same way as a Kaplan turbine. For low wind velocities, its efficiency is twice that of an air-motor operating in free air. Moreover, the rotor diameter can be reduced by 50 per cent.

The excess wind energy can be stored for subsequent use in calm periods by means of a hydraulic pumping system raising water from a lower basin to an upper basin, similar to the systems already extensively used in hydro-electric power plants in Europe and America.

However, particularly in cases where the plant is not connected to a grid, other solutions have been considered, for instance, the accumulation of wind energy in compressed air subsequently used in a gas turbine, or the production of hydrogen by the excess air power used for the electrolysis of water, the hydrogen being stored in special vessels and then utilised in special diesel engines.

The first air-motor power station in the world, based on the designs described in the following sections, is to be erected on the island of Giglio, in the province of Grossetto. This pilot plant will generate a power of 500 kW and the project is now being considered by the Italian Council for Public Works.

WIND CONDITIONS AND LOCATION OF PLANT

The wind conditions in the island of Giglio have been studied since July, 1947, and have also been correlated with the data recorded at the observatory of Orbetello during the last 18 years in order to obtain corrected averages valid for longer periods. Fig. 1 shows a polar diagram of wind frequencies for the year 1948. Fig. 2 gives two typical diagrams with "weighted" values for January and February, 1948, in which the frequencies have been multiplied by the mean wind velocities.

A survey of the data obtained at Orbetello observatory for the last 18 years shows the following averages:—

Wind velocity V	Number of days per annum	
	Occurrence at 8 a.m.	Occurrence at 2 p.m.
$V < 5$ km/h	136·0 days	63·0 days
$5 < V < 35$ km/h	211·9 ,,	277·3 ,,
$V > 35$ km/h	17·3 ,,	24·9 ,,

For a total of 365·2 days per annum, the dominant winds were SE, NW, N and S at 8 a.m., and SE, NW, S and SSE at 2 p.m.

A study of the weighted diagrams such as those of

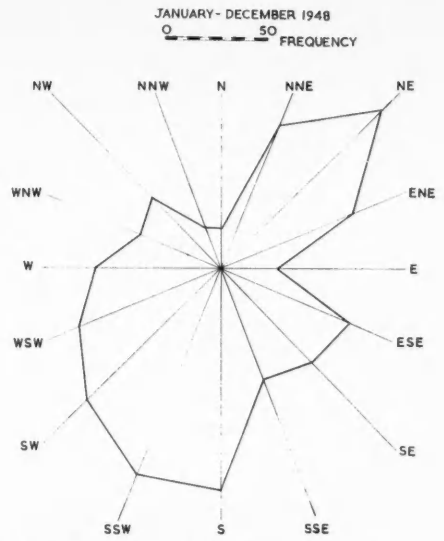


Fig. 1. **Wind frequency diagram for January-December, 1948, at the observatory of Giglio Castello.**

Fig. 2 showed that it would not be possible to use a station with a fixed orientation at Giglio, but that the air aspirating system would have to be designed so that it could be rotated to any required direction.

POWER OUTPUT, EFFICIENCY AND TYPE OF PLANT

The power station project is based on a potential output of 6,400 kWh of energy per day.

The efficiencies of the various parts of the installation can be assessed as follows: d.c. generator $\eta = 0{\cdot}9$; pumps for raising sea water $\eta = 0{\cdot}7$; storage basin for pumped water $\eta = 0{\cdot}9$; impulse water turbines $\eta = 0{\cdot}8$; alternator for three-phase alternating current production $\eta = 0{\cdot}9$; the overall efficiency of the installation is then equal to 40 per cent. This latter figure is for the most unfavourable case, in which the hydraulic storage and pumping systems have to be used. The total wind energy required per annum is, therefore, $6400 \times 365/0{\cdot}4 = 5{\cdot}85 \times 10^6$ kWh.

The power of a propeller-type windmill with blades operating in free air can be calculated by means of the Betz formula:—

$$P_{max} = \frac{16}{27} \rho \frac{V^3 \pi D^2}{2 \quad 4} = 0{\cdot}02\, D^2\, V_m{}^3 \quad [\text{kgm/sec}]$$

assuming that the air density is $\rho = 0{\cdot}125$ and including a factor of 0·65 for the propeller efficiency.

The wind velocities V and the mean velocities V_m, their corresponding durations t, and the energy developed per annum E, can be tabulated as follows:—

V	0–2	2–4	4–5	6–8	..	16–18	18–20	20–22	m/sec
V_m	1·35	3·15	5·1	7·1	..	..	..	..	m/sec
t	514	646	725	572	..	43·8	14·6	14·5	$\times 10^4$ sec. p. a.
P_e	$0{\cdot}5D^2$	$0{\cdot}6D^2$	$2{\cdot}7D^2$	$7{\cdot}5D^2$	..	$100D^2$	$138D^2$	$186D^2$	kgm/sec
E	$0{\cdot}7D^2$	$10{\cdot}5D^2$	$51{\cdot}7D^2$	$116D^2$	..	$120D^2$	$54D^2$	..	kWh

The value of E is obtained from the relation

$$E = 9{\cdot}8\, t\, P_e\, D^2/(3{\cdot}6 \times 10^6).$$

The energy available from the highest velocity range of 20-22 m/sec has not been included among those used, since both the windmill and the air-motor have to be protected against such high velocities which may cause damage to the machinery. Taking the sum of the

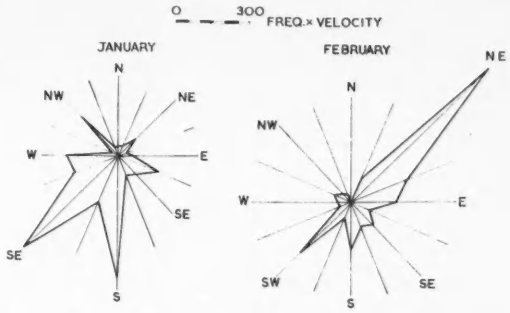


Fig. 2. **Polar diagrams for January and February, 1948, giving the product of frequency and wind velocity, recorded at Giglio Castello.**

energies produced and equating it to the energy required per annum we can now obtain the value of D:—

$$E_{reqd.} = 585 \times 10^4 = 796\, D^2 = \Sigma E$$

hence $D \sim 86{\cdot}0$ metres.

Thus, a propeller windmill with a diameter of 86 m would be necessary to satisfy the requirements when operating in free air. However, if one considers past experience with this type of machine, it is soon realised that the free-air type is impracticable for the purpose contemplated. The largest free-air type of windmill, with a diameter of 54 m and a power of 1000 kW, was built at Grandpa's Knob, Vermont, U.S.A. After about one year of intermittent operation, corresponding to approximately one month of continuous operation, one of the propeller blades broke off. The unbalance forces acting on the machine were then sufficiently strong to cause severe damage to the framework, so that the entire plant was abandoned.

The new installation at Giglio had to be designed so as to operate under severe conditions. The use of a number of smaller air-motors of 38 m blade diameter (the maximum allowable for adequate safety) would have meant 10 plants of 200 kW each, complicating the installation enormously and raising the costs to a prohibitive level.

Contrasting with the above, Professor Vezzani's type of completely-enclosed air-motor offers much more favourable possibilities. The following calculations were made by P. Teofilato, Professor of Aerodynamics at the University of Rome: The Venturi arrangement accelerates the air at the inlet, which reaches an inlet velocity $1\frac{1}{2}$ times greater than in the case of a simple straight tube. Moreover, even in a straight tube, the propeller reduces the air speed to about two-thirds of its value at the inlet. Therefore, with a Venturi-propeller combination, if $V_\infty = 6$ metres per second (mean wind velocity at Giglio), the inlet velocity will be $V_0 = 9$ m/sec, and at the propeller $V_1' = 7$ m/sec for the air stream.

However, by virtue of the law of continuity, the velocity at the propeller will also be increased as the square of the ratio of the inlet and throat diameters D_0/D_1. Thus, if the inlet diameter is $D_0 = 7$ m, and the throat diameter $D_1 = 3{\cdot}5$ m, we obtain

$$V_1 = V_1'\,(D_0/D_1)^2 = 7 \times 4 = 28 \text{ m/sec.}$$

Assuming a flow loss of 3 m/sec up to the propeller, we then have an effective air velocity at the propeller of 25 m/sec. With the type of air-motor considered, a propeller of 10 metres diameter could therefore supply a power

$$P_e = 2\,\pi\,\rho\,D_1{}^2\,V_1{}^3/27 = 145 \text{ kW.}$$

The calculation assumes that the air behaves as an incompressible medium and that the air-motor effi-

ciency is equal to unity. In reality, there is a gradual decrease in air density in the converging portion of the Venturi tube, and a recompression in the tail.

To assess the magnitude of the error due to assuming a constant density, we can write

$$\Delta p = p_0 - p_1 = \rho h V_1^3/2$$

where p_1, V_1 = pressure and velocity at propeller, ρ = air density, and h = coefficient depending on the Reynolds' number R_e of the flow:

$$h = (6 \log_{10} R_e - 14{\cdot}986)/1{\cdot}155,$$

this equation being valid at least up to $R_e = 10^7$. In the case being considered, $R_e = 2{\cdot}5 \times 10^6$, hence $h = 14$ and $p = 562$ kg/m², or approximately 5·4 per cent of the normal pressure. Assuming adiabatic conditions, we have $\Delta p/p = 1{\cdot}4\ \Delta\rho/\rho = 0{\cdot}054$, so that $\Delta\rho/\rho = 3{\cdot}8$ per cent. This shows that the relative change in density is negligible.

The air-motor efficiency can be of the order of 80 per cent if the blade shape and pitch are suitably determined for the coefficient $\gamma = V_\infty/(nD_p)$, where n = rotor rpm, D_p = propeller diameter, and V_∞ = velocity of dominant wind. For the system with an inlet diameter of 20 m, the effective power is then $0{\cdot}8 \times 145 = 116$ kW. For a 500-kW output, an inlet area of 1600 m², corresponding to an inlet diameter of 45 m, is required.

A noteworthy fact is that the power due to the kinetic energy of the wind at the inlet is proportional to $\rho V_\infty^3/2$ [kgm/sec] and reaches a value of only $1600 \times 0{\cdot}214 = 342$ kW, when $D_0 = 45$ m and $V_\infty = 7$ m/sec. The remaining energy is provided by the pressure drop in the convergent portion of the Venturi tube, which is utilised by the propeller, whereas in a normal Venturi the pressure builds up again after the throat section.

The aspirating effect can, moreover, be further improved by suitable design of the tail exit using specially-shaped fixed or rotating units with vanes or baffles arranged at low-pressure positions situated in the last portion of the diffuser and directed vertically upwards.* The effects have been confirmed by wind-tunnel tests, using " Savonius " type rotors with their axis perpendicular to the air flow. Some typical designs of these patented features are shown in Fig. 3.

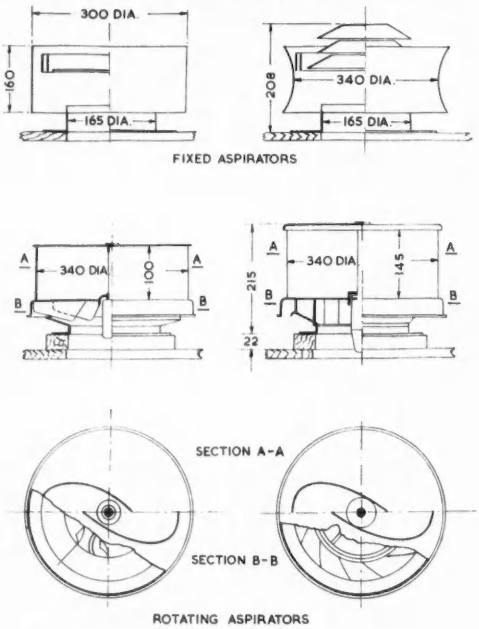


Fig. 3. **Types of fixed and rotating aspirators.**

On the basis of the pressures determined in the wind tunnel tests and taking account of the decelerating effect of the air-motor, the increase in air-current velocity obtainable with these systems is even greater than the value of 1½ times the inlet velocity, which was indicated in the calculations by Teofilato given above. It thus appears reasonable to assume an efficiency $\eta = 80$ per cent for the air-motor operating under average load conditions. Moreover, owing to the increased air velocity, the power available is also increased to $(1{\cdot}5)^3 = 3{\cdot}37$ times its original value.

The conventional propeller windmill had an efficiency of 60 per cent, owing to its gear wheel losses and frictional losses occurring during changes in direction. The built-in motor with its efficiency of 80 per cent is, therefore, 33 per cent more efficient, and the resultant power increase is $3{\cdot}33 \times 1{\cdot}33 = 4{\cdot}48$. The Venturi inlet diameter can thus be made $\sqrt{4{\cdot}48} = 2{\cdot}12$ times smaller for the same power developed, so that $D_0 = 86/2{\cdot}12 = 40$ metres.

CALCULATION OF THE AIR-MOTOR

The design of the Venturi tubes to be used on the island of Giglio has been based on a diameter of 40 m for the inlet, and 10 m for the minimum cross-section of the tubes. The calculations have been worked out for a maximum allowable wind velocity of 20 m/sec. The velocity V_1 at the propeller is taken as 44 m/sec, and the propeller will be designed so that its peripheral velocity is 4·5 times V_1, so that

$$U_{\text{periph}} = 4{\cdot}5 \times 44 = 198 \text{ m/sec}$$

The propeller speed is therefore

$$n = 60\, U_{\text{periph}}/(\pi D) = 60 \times 198/31{\cdot}42 = 378 \text{ rpm.}$$

The maximum power calculated with an efficiency of 75 per cent in place of the mean value of 80 per cent is

$$P_{\max} = 1{\cdot}25 \times 0{\cdot}000285\, V_1^3 D^2 = 3035 \text{ kW.}$$

The effective power can be estimated as being on average equal to two-thirds of this figure, so that we thus have an output of approximately 2000 kW for the installation.

As previously stated, the operation of the enclosed air-motor may be regarded as similar to that of a Kaplan turbine. The compressibility of the fluid has a negligible effect at the very low speeds considered.

The propeller blades can be calculated in the same way as for aircraft propellers, determining the optimum angle of incidence for maximum thrust in the direction of motion, so as to obtain the maximum efficiency. The flow conditions can be determined in three dimensions to arrive at values which will be much more accurate than those obtainable with other known methods.

The smaller size air-motor used in the tubular system makes a sturdier design possible which will withstand mechanical and dynamic stresses due to the wind and centrifugal forces, while practically eliminating all the vibration trouble which occurs in conventional designs with extremely large blading. Moreover, the static aspirating devices at the diffuser exit will have a smoothing effect on sudden wind gusts and therefore act in the same way as a flywheel in a mechanical system.

The air-motor regulating devices, operating according to the wind velocity and load variations, are adapted from the Kaplan turbine system to the enclosed air-motor system. The hydraulic controls are, however, replaced by anemometric pick-ups of the Pitot tube

*It appears that, in view of tests still in progress, the author does not wish to indicate the exact location of the draught increasing devices.—Editor, E.D.

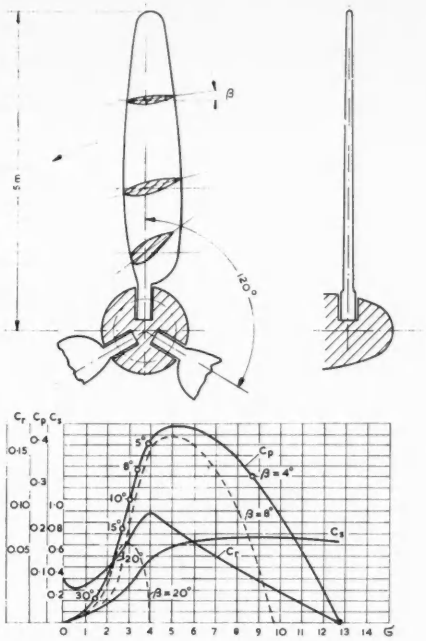


Fig. 4a. **Sketch of variable-pitch propeller, and diagram showing power coefficient C_p, torque C_T, and axial thrust C_s, as functions of $\sigma = u/v$ (based on wind tunnel tests).**

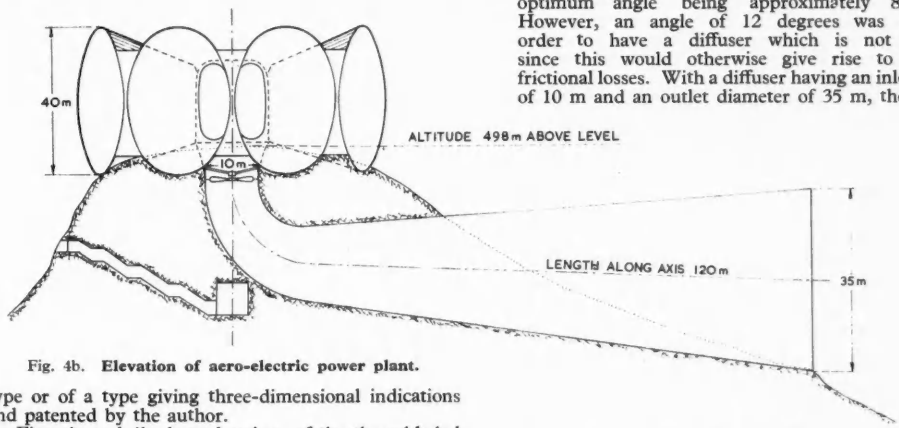


Fig. 4b. **Elevation of aero-electric power plant.**

type or of a type giving three-dimensional indications and patented by the author.

Figs. 4a and 4b show drawings of the three-bladed propeller and of the air duct system. The air-motor is not placed at the throat but approximately at $\frac{1}{3}D$ below this diameter, that is, at 3·33 metres downstream. This gives a better utilisation of the "vena contracta" which, as is known, moves away from the wall of the tube and has its greatest contraction at the position chosen for the air-motor. The displacement of the air-motor also allows the throat diameter to be increased from 10 to 11·8 metres so as to reduce the divergence of the tube in its downstream or diffuser portion by 1 degree, while the convergence of the inlet portion, with an angle of taper of about 35 degrees, will be closer to the optimum value of 30 degrees.

DESCRIPTION OF EQUIPMENT

Directly below the approximately 20-metre long shaft of the air-motor is the main d.c. generator or Ward-Leonard type machine, which can be used either to produce electrical energy for the pump system, or for supplying the energy for the production of the three-phase alternating current at constant voltage and frequency. The general lay-out of the installation is shown in the sketch of Fig. 5.

The delicate electrical and hydraulic control devices for the blade pitch regulation are protected from the weather by being installed underground and are easily accessible. The anemometric devices are erected above the aspirating ducts.

The power station can operate under a wide range of wind and load conditions. The various possible combinations which have been foreseen are illustrated and analysed in Fig. 6.

The eight aspirating ducts have inlet funnels which are nearly elliptical in shape. They are grouped together and constructed of reinforced concrete in the same way as large aircraft hangars. At the centre, inside the aspirating system, is a rotatable semi-spherical baffle or half-cupola which is electrically controlled by the anemometer devices, and which is provided with smoothly-faired transitions leading the air to the air-motor. The half-cupola is situated with its vertical axis in the 10-metre diameter throat section at the beginning of the diffuser, which has a short vertical portion followed by the inclined outlet duct.

The performance of the Venturi-airmotor system is mainly dependent on the efficiency of the diffuser, that is, on its ability to convert kinetic energy into potential energy. Experiments with models using compressible gases and liquids showed that small angles of divergence were more favourable than larger angles, for the formation of a depression the optimum angle being approximately 8 degrees. However, an angle of 12 degrees was chosen, in order to have a diffuser which is not too long, since this would otherwise give rise to additional frictional losses. With a diffuser having an inlet diameter of 10 m and an outlet diameter of 35 m, the length of the diffuser is then $(17{\cdot}5 - 5{\cdot}0)/\tan 6° = 119$ m. The diffuser is orientated in the WNW direction, which is the least exposed to the winds, and is semi-encased in the ground.

The effective power output P_e of the system, using aspirating ducts of 40 metres, has been calculated as follows for the various velocity ranges V:—

V m/sec	0–2	2–4	4–6	6–8	8–10	10–12	12–14	14–16	16–18	18–20
P_e kW	0·8	9·6	42·8	120	234	428	700	1090	1600	2000

Using the wind data previously given, the total energy produced each month has been calculated, the overall efficiency of the system being taken as 50 per cent. The average energy of 19×10^4 kWh required per month

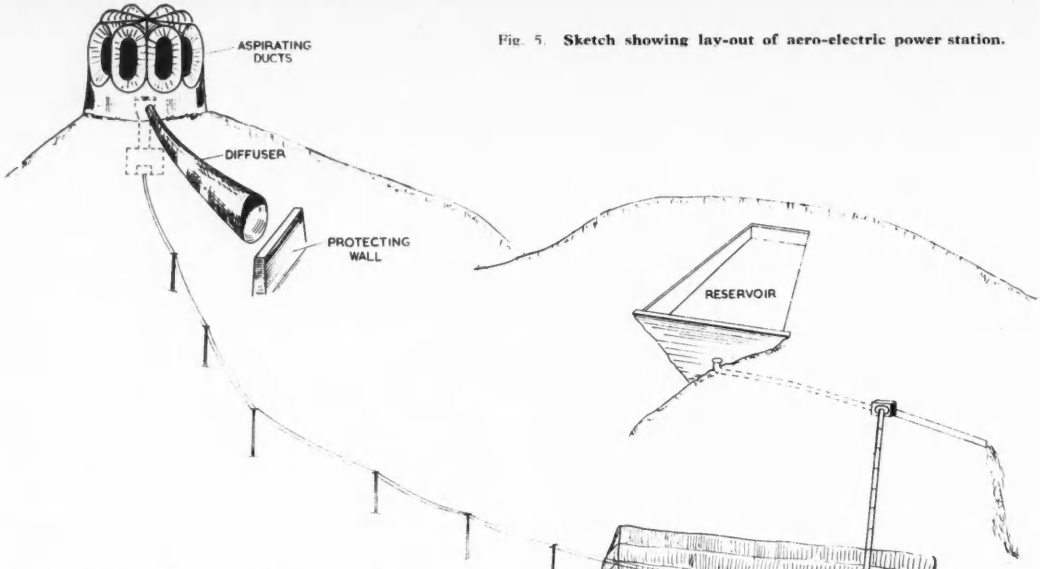
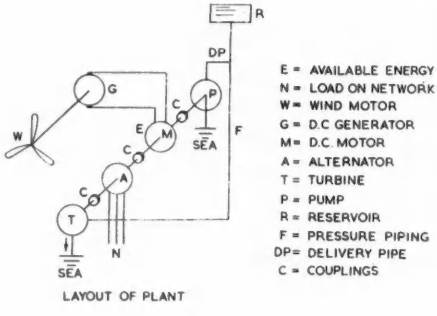


Fig. 5. **Sketch showing lay-out of aero-electric power station.**



LAYOUT OF PLANT

(on the basis of 300 kW for 16 hours and 200 kW for 8 hours daily) can easily be supplied except during the months from June to September, in which there is a deficiency of energy $E_s \sim 12{\cdot}8 \times 10^4$ kWh for the entire period. This energy would therefore have to be accumulated in a reservoir, with a capacity C given by the formula

$$E_s = C\,\Sigma h_m/500$$

where $\Sigma h_m = 70$ m (average head), hence $C = 914{,}285$ m³. However, it was not possible to find a suitable location for a basin of this capacity on the island, and a smaller reservoir will therefore be built. The residual amount of 5×10^4 kWh still required will be supplied by a stand-by diesel-electric generator set during July and August.

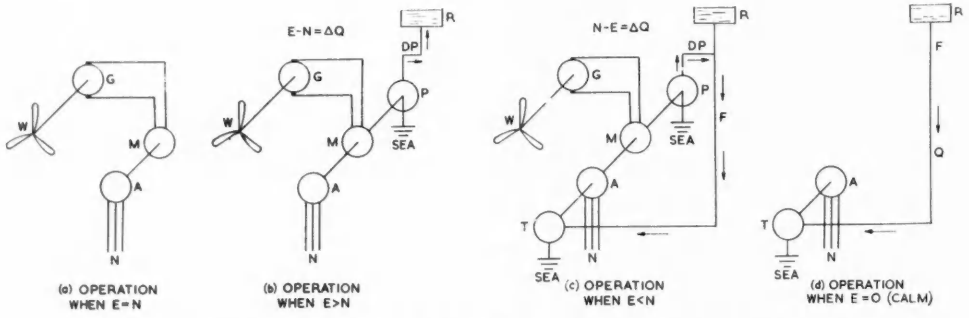


Fig. 6. **Schematic diagrams showing various possibilities of operation of the installation.**

The Design of Bearings for Piston Engines

APPLICATION OF THE THEORY OF EFFECTIVE LOADS

By A. K. DYACHKOFF. (From *Izvestiya Akademi Nauk, S.S.S.R.*, No. 11, November, 1950, pp. 1615-1644, 8 illustrations.)

(*Concluded from April issue*).

THE CENTRIFUGAL LOAD COMPONENT ON THE BIG END BEARING

In this case, the co-ordinates rotate with the crankshaft, R being directed from the crankpin centre through main journal centre, the T-axis being placed at right angles to it in the direction of rotation (see Fig. 6, p. 122, April, 1951).

The projection on R of the centrifugal load caused by the cylinder gases during compression is :

$$R_{ZG\,co} = \frac{1}{\pi}\int_{\pi}^{2\pi} p_{co}\frac{\cos(\alpha+\beta)}{\cos\beta}d\alpha - 1$$

$$\frac{p_c}{\pi}\int_{\pi}^{2\pi}\frac{[B_0+\cos\alpha+B_2\cos2\alpha+B_4\cos4\alpha+B_6\cos6\alpha]\,d\alpha}{\left[1+A\,\frac{\epsilon_z-1}{2}\right]^{n_1}} - 1 \qquad (25)$$

and during the expansion stroke

$$R_{ZG\,exp} = \frac{p_z}{\pi}\int_{0}^{\pi}\frac{[B_0+\cos\alpha+B_2\cos2\alpha+B_4\cos4\alpha+B_6\cos6\alpha]\,d\alpha}{\left[1+A\,\frac{\epsilon_z-1}{2}\right]^{n_2}} - 1 \qquad (26)$$

with the general expression

$$R_{ZG} = \frac{j_1 p_c + j_2 p_z - 2}{2i} \qquad .. \quad (27)$$

where j_1 and j_2 are substituted for the integral in eqs. (25) and (26) respectively, divided by π.

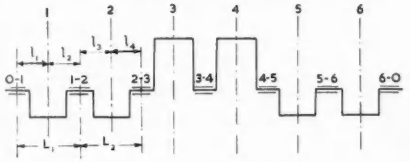
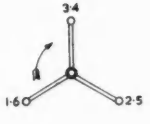


Fig. 7a



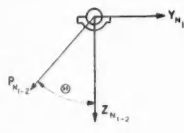


Fig. 7b

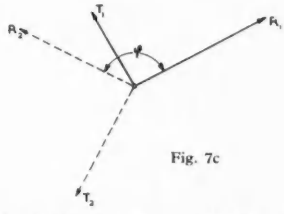


Fig. 7c

The projection on R of the centrifugal component of the inertia forces of the reciprocating masses is :—

$$R_{Z_p} = \frac{1}{2\pi}\int_{0}^{2\pi} p_j\frac{\cos(\alpha+\beta)}{\cos\beta}d\alpha \qquad .. \quad (28)$$

which, after expressing the angular functions in the form of series, simplifying and integrating, gives with k_1 from expression (17b) :

$$R_{Z_p} = -k_1\left(\frac{1}{2}+\frac{1}{4}\lambda^2+\frac{3}{16}\lambda^4+\frac{5}{32}\lambda^6\right) \qquad (29)$$

The projection on R of the centrifugal component of big end loads caused by the inertia of rotating masses is identical with that force, but of opposite direction :

$$R_{Z_c} = -C_{CR} \qquad .. \quad .. \quad (30)$$

Thus, the total projection of centrifugal load components on the big end bearing is :

$$R_Z = \frac{j_1 p_c + j_2 p_z - 2}{2i} - k_1\left(\frac{1}{2}+\frac{\lambda^2}{4}+\frac{3\lambda^4}{16}+\frac{5\lambda^6}{32}\right) - C_{CR} \qquad (31)$$

This indicates that the magnitude of the sum of the projections on the crankweb axis of the centrifugal component loads on the big end bearing varies with engine speed and power. During starting and at low speeds it is directed from the crankpin towards the main journal. With increasing speed, the value of this resultant component decreases, passes through zero and then increases again, but in the direction from the main journal to the crankpin. This point is of importance, and will be referred to again later.

The projection on the T-axis of instantaneous forces due to gas pressure is :

$$T_{ZG} = \frac{1}{i\pi}\,p_i \qquad .. \quad .. \quad .. \quad (32)$$

where p_i is the i.m.p. during the expansion stroke. The respective components of the reciprocating and centrifugal inertia forces are zero.

The total centrifugal load component on the big end bearing is :—

$$P_Z = \sqrt{R_Z^2 + T_Z^2} \qquad .. \quad (33)$$

and its direction

$$\tan\Theta_Z = T_Z/R_Z \qquad .. \quad (34)$$

is greatly influenced by the speed and power of the engine.

CALCULATIONS OF LOAD COMPONENTS ACTING UPON MAIN BEARINGS

The "static" and centrifugal load components acting upon the big end bearing are transferred to adjacent main bearings. To the centrifugal components must, of course, be added the vectorial forces contributed by the masses of the crankpin, crankweb and balance weights.

Examining a six-cylinder in-line engine crankshaft with seven main bearings (see Fig. 7a), the latter are given the numbers of adjacent cylinders as indicated. For the examination of "static" load components, fixed co-ordinates are used again in the case of main bearing (1–2), $Y_{N_{1-2}}$ and $Z_{N_{1-2}}$ as shown in Fig. 7b. It follows that the Z-component for this bearing

$$Z_{N_{1-2}} = Z_N(l_1/L_1 + l_1/L_2) \qquad .. \quad (35)$$

and the Y-component

$$Y_{N_{1-2}} = Y_N(l_1/L_1 + l_1/L_2) \qquad .. \quad (36)$$

where L_1 and L_2 are the distances between main bearing centres, and l_1 and l_4 the distances between centres of crankpins and main bearings as shown in Fig. 7a. The direction Θ_N (see Fig. 7b) is easily calculated.

In calculating the centrifugal load component of the main bearing, the relative direction of the two adjacent crankwebs is important. The co-ordinates are arranged as follows : R_{1-2} along the axis of one of the crankwebs (see Fig. 7c), and T_{1-2} perpendicular to it in the direction of rotation. The appropriate part of the load vector of the first crankpin is transferred whole, but that for the second crankpin is corrected for direction of the new co-ordinates.

$$R_{Z_{1-2}} = R_{Z_1}\frac{l_1}{L_1} + R_{Z_2}\frac{l_3}{L_2}\cos\varphi + R_{K_1} + R_{K_2}\cos\varphi - T_2\sin\varphi\,\frac{l_3}{L_2} \quad .. \quad (37)$$

$$T_{Z_{1-2}} = T_{Z_1}\frac{l_1}{L_1} + T_{Z_2}\frac{l_3}{L_2}\cos\varphi + R_{Z_2}\frac{l_3}{L_2}\sin\varphi + R_{K_2}\sin\varphi \quad .. \quad (38)$$

where R_{K1} and R_{K2} are the centrifugal forces of the crank-webs and of half the crankpins of the respective cranks of the first and second cylinder, φ the angle between the cranks, T_1 and T_2 are the projections on the T-axis of the centrifugal load component of big end bearings 1 and 2, and R_{Z_1} and R_{Z_2} are the projections on the R-axis of centrifugal load components of big end bearings 1 and 2. Usually, $R_{Z_1} = R_{Z_2}$ and $T_1 = T_2$. The magnitude of the resultant force and its direction are easily estimated from the projections.

Determination of Bearing Loads for other than In-Line Multi-Cylinder Engines

In principle, the same method of determining the projection, on suitably chosen co-ordinates, of the load components can be applied as shown in the preceding paragraphs. With a " V " engine, for example, the aggregate " static " load on the common big end bearings of two cylinders I and II (see Fig. 8) is determined by combining the vectors $P_{N\,I}$ and $P_{N\,II}$ of each cylinder, each of these vectors including an angle Θ_N with the axis of its cylinder.

With Φ the angle between the cylinder axes, the " static " load on the big end is :

$$P_{N\,I-II} = [(Z_{N\,I} + Z_{N\,II}\cos\Phi + Y_{N\,II}\sin\Phi)^2 + (Y_{N\,I} - Z_{N\,II}\sin\Phi + Y_{N\,II}\cos\Phi)^2]^{1/2} \quad (39)$$

based on projections on $Z_{N\,I}$ and $Y_{N\,I}$. Its position relative to the axis of cylinder I is given by

$$\tan\Theta_{N\,I-II} = \frac{Y_{N\,I} - Z_{N\,II}\sin\Phi + Y_{N\,II}\cos\Phi}{Z_{N\,I} + Z_{N\,II}\cos\Phi + Y_{N\,II}\sin\Phi} \quad (40)$$

Similarly, the centrifugal component forces are combined. Main bearing loads are found from big end loads in a similar manner to that indicated for the in-line engine.

The same method, suitably modified, is applicable when determining bearing loads for more complicated cylinder arrangements.

III. SEVERAL OBSERVATIONS ON THE APPLICATION OF THE THEORY OF EFFECTIVE LOADS TO THE DESIGN OF ENGINE BEARINGS

It is claimed that the theory of effective loads makes it possible for the first time to determine the correct position for oil holes. If the " static " component of the load on a bearing is greater than the centrifugal component, the oil hole should be placed in the bearing. If the centrifugal component is the greater, the oil hole should be placed in the journal. The position of the oil hole itself is determined by the direction of the " static " load vector in the former case, and by that of the centrifugal load vector in the latter case.

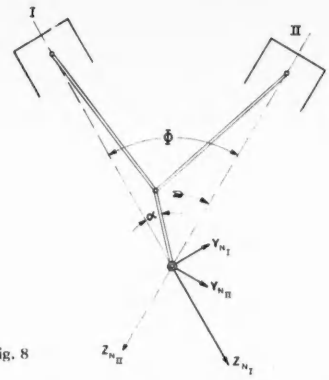


Fig. 8

The balancing weights on the crankshaft should be placed opposite the vectors of the centrifugal load components and not opposite the vectors of the centrifugal forces due to the effects of the connecting rod, crankpin and crankweb.

From the point of view of lubrication, it appears that complete balancing of the centrifugal forces of a crankshaft may lead to dangerous results. If the lubricating oil is supplied from a common header to the individual main bearings and through oil holes drilled through main journals, crankwebs and crankpins to big end bearings, too small a centrifugal load on the main bearings may impair the oil supply to the big ends. With a predominantly static load on the main bearing, the oil hole leading to the big end bearing during rotation passes through parts of the main bearing oil film which are under a very low oil pressure. This creates pulsations in the oil flow to the crankpin, so that the oil supply to the big end, cylinder and piston is reduced. It is concluded that the centrifugal component on the main bearing should not be less than the static component.

At low-speed operation of the engine, the static load component is generally bound to be greater than the centrifugal. From the explanation given in the preceding paragraph, this means that during starting and while warming up at low speed, the lubricating oil supply to essential parts is impaired just when it is most needed. The only way of preventing excessive wear of cylinders, big ends and crankpins, is to raise engine speed rapidly above what may be called " the critical speed " in regard to lubrication, i.e., the speed at which " static " and centrifugal load components are equal. Also, an engine should never be idled at low speed for any length of time.

As the direction of the centrifugal load component varies with engine speed and power, several, say three, oil holes are recommended to be placed in the crankpin, the middle opening in the optimum position for maximum speed and power, and the two lateral bores for low-speed and high-load operation.

If the crankshaft is bored right through to supply oil to the main and big end bearings, the importance of the prevailing centrifugal load components for both types of bearings is accentuated. With this system of lubrication, it is especially dangerous to operate at speeds below the critical speed and the arrangement should be applied only to stationary engines operating at constant speed.

BRITISH INDUSTRIES FAIR 1951

April 30—May 11

We continue below the description of some of the displays at the British Industries Fair which opened on April 30th and closed on May 11th. According to the summing up of the organizers, the success of the 30th B.I.F. has been beyond all expectations.

The total of overseas visitors to the three sections of the Fair at Olympia and Earls Court, London, and Castle Bromwich, Birmingham, was higher than the record number attending the B.I.F. last year. Moreover, the percentage of genuine buyers was higher than ever.

The attendance of home buyers was, however, 12 per cent lower than last year. The reason for the poor attendance of home buyers might have been that British industry has anticipated the increasing demand, following the rearmament programme, and had built up stockpiles for some months.

Overseas buyers complained about extended delivery dates, but there have been few complaints about prices. Some overseas buyers were astonished about shortages of raw materials in Britain, especially as exhibitors at the recent Fairs at Zurich, Hannover and Milan seem to suffer less on that account than the British industry. An explanation might be found in the comparatively much lower capacity of the Swiss, German and Italian engineering industries.

The largest contingent of overseas buyers came this year, for the first time, from Australia. Holland, South Africa, Eire, the United States and France, followed in that order. Canada was on the eleventh place.

A justifiable complaint of many home and overseas visitors is the lack of amenities. Improvements in transport facilities, hotel accommodation, more and better restaurants and entertainments, would be an attraction and would greatly contribute to the success of the British Industries Fair, this great and important national enterprise.

J. Brockhouse & Co. Ltd. and Associated Companies have shown many of the products manufactured and marketed by the companies of the Group. The range includes the Brockhouse-Salerni Torque Convertors; Castings, Forgings and Cold Rolled Sections; Automatic Boilers and Heater Equipment; Lightweight Petrol Engines; Chatwin Small Tools and Machine Tools; B.M.B. Marine Engines and John Brooks all-steel Anvils and Vices.

The Conveyancer Fork Truck Co. (Division of Electro-Hydraulics Ltd.) has shown various Fork Lift Trucks. *Model E2-20/3W* is a battery electric truck which is a new production. It is a three wheel truck with a load capacity of 2,000 lb. at 20 in. from the heel of the forks and a standard height of lift of 9 feet. It has a travelling speed of 4½ m.p.h. and can comfortably negotiate 10 per cent gradients. A particular feature of this "Conveyancer" Fork Truck is a single unit driving mechanism which can be readily removed for servicing. This model has been specially designed for operation in minimum width gangways, its extremely small outer turning radius giving it exceptional manoeuvrability. Special attention has been paid in the design of this truck to reduce time spent on servicing to a minimum. Readily removable panels give access to all components. The elevation of the load and tilting of the mast are, as in all "Conveyancer" trucks, effected hydraulically, power being derived from a high efficiency electrical driving pump.

Model 6020. *PT* is powered by an internal combustion engine. It has a load capacity of 6,000 lb. at 20 in. from the heel of the forks and has a standard height of lift of 12 feet. The outstanding feature of this truck is that it has no clutch or gearbox, the engine torque being transmitted through a hydraulic turbo-drive and automatic gearing. The turbo-drive is a simplified model of similar units which have already seen several years of heavy tractor service. It has virtually no wearing parts and thus the servicing and maintenance associated with normal clutch and gearbox drive has been eliminated. The engine is the well known petrol engine fitted to the Ferguson tractor. A diesel engine can be supplied as an alternative. The truck is four wheeled with pivoted steering axle for negotiating uneven roads and is extremely robust throughout. Special twelve-ply pneumatic tyres are fitted as standard but solid or cushion tyres are supplied as required. Accessibility for servicing is also a noteworthy feature.

Cowlishaw, Walker and Co. Ltd. have featured the 75-ton "O.T. 60," one of the most versatile models from a complete range of presses whose clean functional design is combined with strength and rigidity. It was originally intended for auxiliary press operations in motor car body shops and is still extensively used for this work, but it has since proved itself a most valuable general purpose machine. It has an adjustable bed which can be swung out of the way while special knee beds are bolted on to it, and it can also be made as a horning press.

An item of special interest was a working model of the C.W. patent air-operated clutch-brake unit. The circuit for the electrical clutch control was worked out in conjunction with the Metropolitan-Vickers Electrical Co. Ltd., and push-button control provides a variety of clutch sequences.

The smooth, direct action of the unit itself absorbs shock loads and allows easy inching for tool-setting purposes, while ample friction surfaces ensure long life in the clutch plates without frequent adjustment. This clutch-brake unit is fitted to all C.W. presses of 100 tons capacity or more.

Dunlop General Rubber Goods and Dunlop Special Products (Engineering Components) Divisions had a combined stand to show ebonites, rubber mouldings, protective aprons, Nerflex utensils, all types of hose, v-belts, silicones, industrial gloves, miners' knee

FBC TRADE MARK

ALL-BRITISH

BALL & ROLLER BEARINGS

Ball and parallel-roller bearings for every purpose.

The illustration shows F.B.C. ball and parallel-roller bearings on the pinion-shaft of a motor coach five-speed gear box.

FISCHER BEARINGS CO. LTD., WOLVERHAMPTON

Subsidiary of British Timken Ltd.

and elbow pads, rollers, conveyor belting, transmission belting, tank linings and anti-corrosion units, oil industry rubbers, rubber flooring, mats and nosings, and pure india rubber tape (insulation).

Dunlop Special Products displayed a range of rubber engineering components designed and manufactured to precision limits, including flexible power transmission couplings, disc and barrel types; anti-vibration mountings for instruments and machinery; and among the rubber suspensions a motor cycle with front and rear suspension.

Electromagnets Ltd. has shown a comprehensive range of both permanent and electromagnetic separators, including magnetic pulleys, chute type separators, swarf separators, etc.

The newly developed super intensity magnetic feeder unit, representing a great advance in magnetic extraction, has also been exhibited. These machines are the subject of world patents.

The feeder unit takes the general form of a short band conveyor, but the conventional magnetic pulley which is widely used on such plants is replaced by an entirely new Magnetic Head, around which is contoured the rubber and canvas conveyor belt. Limitations of space of magnetic circuits and windings which are normally imposed by pulley or drum diameter are completely removed, and the intensity of magnetic field is increased three or four times. A continuous discharge of tramp metal is also provided.

Foster Yates & Thom Ltd. has featured a newly developed Fully Automatic 50 Ton Moulding Press. It is a completely self-contained unit of modern appearance. Much thought has been given to the functional design of the main frame which consists of a fully fabricated and stress-relieved unit, providing ample strength and rigidity, ease of access for servicing and many operating and installation advantages.

Various tooling economies possible with this press, make it equally suitable for short or long production runs.

One of the outstanding features of the **Guest Keen & Nettlefold** display at the B.I.F. Birmingham this year was a section of permanent way, which incorporated specimens of all the Railway fastenings and accessories manufactured by the G.K.N. Group of Companies.

These fastenings and accessories include Sleepers, Chairs, Baseplates, Keys, Clips, "T" Bolts, Spike Anchors, Dog Spikes, Fang Bolts, Crossing Bolts, Chair Bolts and Fish Bolts.

The Companies represented in this particular exhibit were Guest Keen & Nettlefolds (Midlands) Ltd., Guest Keen & Nettlefolds (Cwmbran) Ltd., Exors of James Mills Ltd., and Bayliss, Jones and Bayliss Ltd. Other members of the Group were represented on the Main Stand in the Exhibition Building and on the special outdoor Stand.

The principal wrought metal products of the **I.C.I. Ltd.,** Metals Division: strip, sheet, plate, tubes, rods, sections and wire in copper and its alloys and aluminium and its alloys were exhibited, in small display units of massed metal.

Illustrating one of the many activities of the Division's Research Department there was a small team at work determining the stresses set up in various non-ferrous wrought metals, during and after welding, the object then being to adjust welding practice so that welds with the minimum amount of stress are produced. There was also a display of radiographs of finished welds; and an arrangement for taking such photographs using a "gamma bomb."

Demonstrating the constant interest of the Division in solving problems of corrosion and erosion in condenser tubes, the stand contained a typical circulation test apparatus of the type in day to day use in the Division. The data obtained forms the basis of a subsequent recommendation for the most suitable condenser tube alloy for service under the conditions investigated.

Copper tubes for domestic water, gas and sanitation services together with appropriate fittings were displayed and also "Kuterlon" long length copper tubing for underground water supplies and panel heating.

Photographs of extrusions supplied for use in the main ribs of the Dome of Discovery at the Festival of Britain, and extrusions for aluminium alloy railway coaches now being constructed were also exhibited.

The Plastics Division stand of **I.C.I.** was devoted to the uses of plastics in the engineering industries. Particular attention was given to the use of nylon moulding powder for the moulding of small bearings, rings and similar components where the toughness and self-lubricating properties of this plastic can be exploited. Polythene tubing for water service lines was shown and the technique of jointing and welding illustrated. Another feature was polythene film for protective packaging and polythene chemical plant made from granules or sheet material. "Perspex" acrylic sheet for machine guards, canopies and screens, as well as corrugated "Perspex" roof lights, in clear and coloured grades were on view, and also "Diakon" industrial mouldings, particularly electrical accessories.

Mavitta Drafting Machines Ltd. exhibited a complete range of Drafting Machines to fit boards of all sizes up to 84 in. × 44 in. and upwards, mounted on adjustable drawing stands, an adjustable set square and a selection of mathematical scales.

The exhibit included a machine designed primarily for the production of full scale drawings. This machine consists of a travelling Drafting Head which is counterbalanced for easy vertical movement, and can be supplied to cover boards up to fifty feet in length.

All the equipment shown is available for early delivery, both for home and overseas markets.

Various members of the 30 companies comprising the **Owen Organisation** have again exhibited a great variety of engineering products.

C. & L. Hill Ltd. have exhibited a selection of non-ferrous sand castings and chill cast phosphor bronze bars.

E. Camelinat & Co. Ltd. have displayed various types of deep drawn pressings, metal spinnings and light steel fabricated components.

Nuts & Bolts (Darlaston) Ltd. have shown a selection of coldheaded and hot forged black bolts and nuts and "Evertite" patent locknuts.

Invicta Electrodes Ltd. had on display a range of arc-welding electrodes.

Rubery Owen Kepston Ltd. featured the new "Rokvee" copper brazed pressed steel vee belt pulley in various sizes.

Gasel Appliances Ltd. exhibited the "Gasel" 4 cu. ft. Absorption Type Refrigerator for operation by gas, kerosene or electricity.

Salopian Engineers Ltd. have displayed agricultural machinery.

Rapid Magnetic Machines Ltd. has shown the company's "Permaflux" Pulley, Drum and Chute Type Separators for removing iron from processed materials, also an entirely new device called the "Magnatrap" for extracting ferrous impurities from many liquid and semi-liquid products conveyed by pipe line.

High quality steel products must be free from the defects which appear on the surface of the ingot, bloom, slab or billet during the process of steel manufacture. Oxy-Acetylene Hand Deseaming enables individual imperfections of any depth to be removed, either before or after the rolling operation, with a greater degree of precision than is possible with pneumatic chipping and in one tenth of the time—giving a faultless finish with an incalculable saving in man-hours and machine time. The deseaming of ingots illustrated above is just one of the many ways in which B.O.C. processes are aiding production in the Steel Industry !

THE BRITISH OXYGEN CO LTD LONDON AND BRANCHES

Two typical types of magnetic separators for extracting iron from scrap, swarf, borings, etc., were shown in operation.

The Crockett, Laboratory type was exhibited, which is a submerged belt type separator for the positive recovery of cleansing media, i.e., Ferrosilicon and Magnetite as used in heavy media separation process.

Hoppers, spouts and floor openings, prove ideal installations for the "Rapid" Magna-Grid, for extracting any ferrous contents. This equipment was also shown.

For the sheet metal industry, an entirely new patent permanent Magna-Clamp which is adjustable to all angles, will prove invaluable as a welding clamp.

Electro-magnetic Lifting Magnets, Clutches, Brakes, and Overband type Separators were available for inspection, also two new versions of the new Magna Sweep, a permanent magnetic floor sweeper for the rapid and continuous collection of nuts, bolts, wire, swarf, etc., invariably found on workshop and factory floors.

The Streetly Manufacturing Co. Ltd. has shown a representative selection of its mouldings in urea, melamine, phenolic and thermoplastic materials.

The stand was divided into two main parts—a large panel displaying the larger mouldings and two display units showing in greater detail the stages in moulding or finishing some of the smaller or intricate mouldings. Amongst these was a display of printed mouldings, showing the various stages in printing and stoving a 3-colour overprinting; the moulding of a well-known product incorporating components made in *seven different materials* was fully dealt with in another panel. Other subjects included iniection mouldings, electrical plugs and switches, bottle, jar and tube caps, and the moulding of a special beaker.

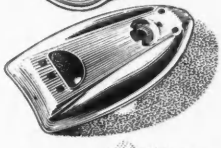
Amongst the mouldings displayed there was a high proportion of technical and electrical mouldings, including electrical meters, slip rings, control knobs and handles, radio cabinets, ventilating and refrigerating components, etc.

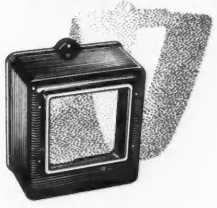
Westinghouse Brake & Signal Co. Ltd. exhibited a series of compressors and exhausters. Braking equipment is manufactured for extensive rail and road uses; air apparatus for heavy duty and passenger service vehicle chassis of several well known makes was shown, including governors, control valves, tyre inflators, relay emergency valves to trailers and a patented form of anti-freezer. Applications of compressed air to industrial practice were featured by Westinghouse manual and electro-pneumatic control gear for conveyor ploughs and stops, small presses, multi-operation machine tools and associated processes.

The conversion of electric power was typified by the feeding of the incoming, single-phase mains supply through a bank of Westinghouse static phase converters to actuate a set of three-phase hoists, which in turn handled lifting magnets operated by Westinghouse metal rectifiers. A range of vehicle battery chargers utilised other types of rectifiers; while a specially developed system using rectifier units for the cathodic protection of buried metal structures against corrosion was demonstrated. These units, now being supplied for 560 miles of Middle Eastern pipe line, for storage tank bottoms at home and other such needs, are of the "Westalite" type, oil immersed, and incorporate an automatic control that maintains the applied current constant against any change of soil resistance.

A model track demonstrated control relays and colour light signals, operated by hand plungers or vehicle treadles. The background to these and other exhibits was provided by a comprehensive display of photographs.

Pressings
Turned Parts
Assemblies





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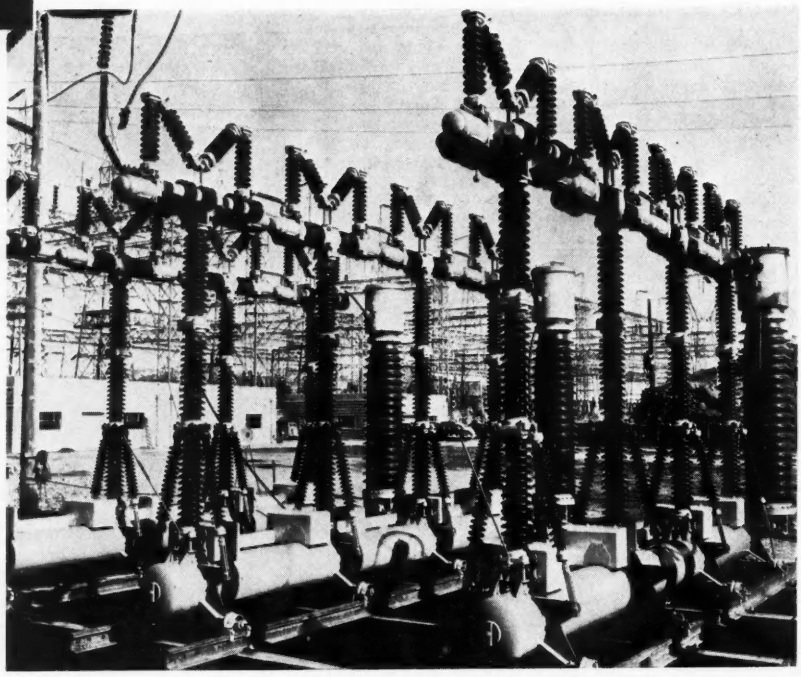

Brown Boveri air-blast breaker in the large switchyard of the Grand Coulee Dam station in which it was tested by American engineers between the 14*th and* 18*th March,* 1951.

The tested breaker is an outdoor model for 220 kV and is rated 6 million kVA according to I.E.C. standards or 9 million kVA for American practice. It coped satisfactorily with all the short circuits initiated during the extensive series of tests, which included reclosing operations, and a final test at a much higher power.

The maximum interrupted power was of the order of 41 million kVA (asymmetrical) at a voltage of 238 kV; the breaking time only $^{5}/_{100}$ sec.

After completion of the tests the contacts were removed in a matter of 6 minutes and found to be fully capable of further service.

The excellent properties of our breakers have thus been corroborated under conditions never hitherto encountered in practical service.

To date a total of 565 three-pole air-blast circuit breakers for service voltages of 120-400 kV have been supplied to 23 countries; of those eight, rated 380 kV, 8·5 million kVA, were for Sweden.

Some other products:

Indoor-Type Air-Blast Circuit-Breakers ● Relays for Electrical System Protection ● Generators ● Transformers ● Switchgear ● Velox Boilers ● Steam Turbines.

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LIMITED
BADEN (Switzerland)

SWISS INDUSTRIES FAIR, 1951

The rearmament programme of the Atlantic Pact nations has greatly contributed to the success of the 35th Swiss Industries Fair which was held in Basle from April 7th to 17th. 670,000 visitors, including about 20,000 buyers from 67 foreign countries, visited the Fair, at which 2,200 exhibitors occupied the one million square feet of exhibition space available. The comparatively large number of buyers from Great Britain, France and the United States, showed keen interest in Swiss machine tools, special machinery, electrical equipment and precision instruments. Despite increasing demand, comparatively favourable delivery dates could in many cases still be obtained for a large range of equipment. Few new machines and fundamentally new types of equipment were exhibited. Some Swiss manufacturers gave two reasons for this lack of technical innovations. Firstly, the Swiss industry, working to capacity on current models, had little time for evolving entirely new designs or completing work on machinery still in the development stage; secondly, many firms were reluctant to show their latest designs at the present time.

Plica, A.G., Rüschlikon (Zurich) showed pliable tubes made of various materials, such as aluminium, lead, brass, copper, lead-coated alloys, etc., to suit any particular application. These tubes are manufactured by an automatic tube-making machine in endless lengths in sizes ranging from $\frac{1}{8}$ to $1\frac{1}{4}$ in. diameter. They can be easily bent by hand and save both time and material in a variety of applications.

Amongst numerous measuring, indicating and controlling instruments shown by **Camille Bauer A.G.,** Basle, the recently developed Total Radiation Pyrometer "Pyruni" is of special interest. It can be used for temperature measurements between 100° C and 3000° C and even higher temperatures. It can be applied for measurements on annealing, melting and hardening furnaces, glass-melting furnaces, combustion chambers, infra-red drying ovens, etc. A mirror collects the radiation, which is directed in a compact beam to the hot-junctions of a multi-element thermopile, consisting of 16 thermocouples per mm². The ambient temperature of the instrument does not influence the accuracy of the measurement as it does not interfere with the radiation between furnace and thermopile. The thermo-e.m.f. arising can be measured across the terminal clamps of the instrument. These clamps are connected with an indicating or controlling instrument, recorder or galvanometer.

Strausak & Cie., Lohn (Soleure), exhibited a well-designed Automatic Pinion-Cutting Machine, with three cutters, for straight teeth, with or without automatic feed. It is designed for work of 0·3 to 6 mm diameter with automatic feed and 0·3 to 12 mm diameter without automatic feed. Maximum cutting length is 12 mm.

The grinding machines shown by **Kummer Freres,** Tramelan, are of distinctive design and quality. Their Type Re 125 is of sturdy construction to permit rapid operation with the highest degree of finish. After the initial set-up, all operations are controlled by a single lever. The table is driven hydraulically and is capable of instantaneous speed variations. It slides within a system of automatically lubricated inverted V-guides. The time for reversing can be adjusted independently on each side of the reverse motion.

The Semi-Automatic Turning Machine shown by this firm comprises two workheads, one for turning and one for loading. Each workhead is controlled by its own motor and is fully independent. It can be fitted with a threading attachment. Applications of this machine include the manufacture of counters, optical instruments, watch cases, fuses, etc.

Contina A.G., Mauren, Liechtenstein, showed small "Curta" universal calculating machines. Owing to the small dimensions of the instrument (approx. $2\frac{1}{8} \times 3\frac{3}{8}$ in.) it can be held in one hand while being operated with the other, or it can be carried in the pocket without inconvenience. The small machine adds, subtracts, multiplies, divides, squares, cubes and extracts square roots with utmost accuracy, high speed and freedom from noise. In addition, some precision gauges used in the manufacture of this machine were exhibited, and these may prove to be of value for the manufacture of other precision products.

Edouard Dubied & Cie. S.A., Neuchatel, showed the Type 512 Production Lathe, which Continental automobile manufacturers have found more economical for turning engine valves, axles and shafts than multi-tool automatic or semi-automatic machines. This is basically a single-tool machine, and tool grinding and setting times are much lower. The hydraulically controlled copying device, recently designed for this machine, facilitates precision turning according to a profile templet, with very short machining times and at reduced setting costs.

Billeter A.G., Neuchatel, exhibited automatically operated universal machines designed for milling, profiling, angle-cutting, drilling, back-milling and engraving precision engineering parts in mass production.

A new hacksawing machine, developed by **Willi Habegger Engineering Works,** Thun, is suitable for cutting heavy T-beams and workpieces of 18 in. × $21\frac{1}{2}$ in. cross-sectional area. The same firm exhibited a new type of metal band-sawing machine, the head and saw-band of which can be tilted up to an angle of 45 degrees.

"Bondycop," an hydraulic copying attachment manufactured by **Bondy S.A.,** Fribourg, can be fitted to any lathe. It is suitable for the production of any shapes, 90-degree shoulders, etc., and simplifies thread cutting.

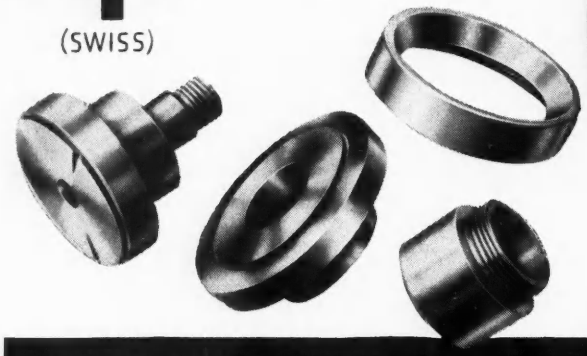
Oma A.G., Zurich, exhibited an oil burner suitable for all grades of fuel oil up to the heaviest. Superheated steam is used to atomise the fuel oil before entering the combustion chamber. The steam introduced into the injectors vaporises the oil. The required oil mist burns in the combustion chamber with a very soft slow-burning flame spread over the entire combustion chamber without causing corrosion or fouling of boiler surfaces. The construction of the burner is simple, the unit having no moving or rotating parts. Backfiring and explosions cannot occur. No smoke, coke or tar can form and, therefore, the fuel is fully utilised. The burner can be built into any type of steam boiler or industrial furnace.

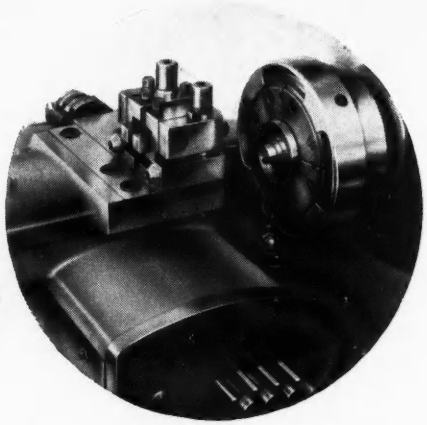
E. Schaffner A.G., Schoenenwerd, showed a general-purpose universal milling machine which can also be fitted with a vertical milling head.

Brown, Boveri A.G., Baden, demonstrated the new arc welding set for 250 and 375A. With the new design of welding current regulator for 10 to 370A, the welding current can be controlled at each point of a multiple installation. This firm also showed a new pneumatically operated automatic spot-welding machine with a purely electronic control enclosed in a separate cabinet. The outstanding exhibit on another stand of the same firm was an electric-boiler over 16 ft high, capable of delivering 33,000 lb per hour of steam at an

KTF (SWISS)

SEMI-AUTOMATIC TURNING MACHINE
TYPE MR6050





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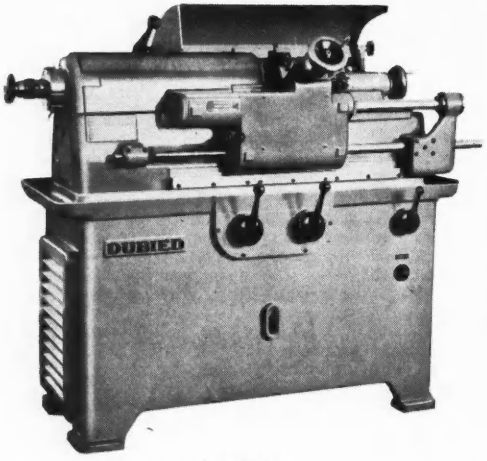
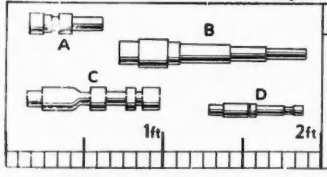
DUBIED Swiss Made

512 PRODUCTION COPYING LATHE

cuts working times





	DUBIED LATHE	NORMAL LATHE
A	6 MINS	18 MINS
B	13 "	28 "
C	10 "	32 "
D	6 "	15 "

MODEL 512

HEIGHT AT CENTRES	**4¾in.**
DISTANCE BETWEEN CENTRES	**15⅞in. or 25⅝in.**
CROSS SLIDE TRAVEL	**3in.**
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operating pressure of 200 psig. This 10,000 kW boiler operates at a voltage of 6,000 volts. A new design of totally enclosed externally cooled loom motor was also exhibited, in which no dust or fibre could settle even under the most unfavourable conditions.

Georg Fischer A.G., Schaffhausen, exhibited copying lathes of the latest design, in which the copying slide is fitted above the work-piece and is also capable of being tilted. When the slide is set at an angle, right-angle shoulders can be copied and the maximum turning length is 26 in. with the copying slide in vertical position and 20 in. when tilted. In both cases, the maximum turning diameter is 5½ in.

Aciera A.G., Le Locle, exhibited their range of drilling and thread-cutting machines as well as three of their well-known milling machines. The smallest of these, Type F1, is a new design, with a table size of 4 × 8¾ in. The milling spindle, in combination with the motor and gearing, forms a unit for horizontal or vertical use as required. This machine is especially suited for making watch cases, as well as in precision engineering and instrument industries.

J. Huber & Cie., Baden, showed a new design of signal lamp, which offers special advantages when built into switchboards, as well as control apparatus for machine tools. This firm has also built for the Swedish State Railways a special forward and reverse switch for traction cars. A master controller operates the control of the relays, which, in turn, control the main motor. This mechanical device, which has to fulfil exacting demands, has been kept within very small dimensions.

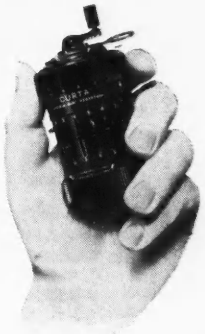
Ateliers de Construction Oerlikon, Zurich, exhibited a variety of electrical machines and equipment. This firm, which has been in existence for 75 years, included among the exhibits a new interference generator which embodies a novel idea for utilising the harmonic fields of slot windings for generating higher frequencies. Machines with frequencies of several thousand cps are used for grid control, remote control of electric boilers, illumination, etc.

Chr. Gfeller, A.G., Bern-Buemplitz, showed a remote control installation equipped with new switch elements and developed on new lines. This installation enables the close and remote control of a transformer substation with 20 circuit breakers and isolating switches, as well as the control and position indication of a stepped transformer and the transmission of various alarm signals.

"Elmes" Staub & Co., Richterswil, exhibited a new universal precision measuring instrument, which includes the special feature of a rectifier unit, the temperature coefficient of which is less than 0·07 per cent. A new portable instrument assembly permits the simultaneous measurement of current, voltage and wattage in single and three-phase networks.

Tornos S.A., Moutier, exhibited automatic lathes which have been fitted with "Micronic" adjustable needle bearings. By adjusting a micrometer screw, the play in the bearings is adjustable within very fine limits. The bearing is suitable for precision turning as well as for rough work at high speeds.

Movomatic S.A., Neuchatel-Monruz, exhibited an electrical gauge and control instrument for cylindrical and internal grinders, which is capable of accurately gauging the work during grinding. A rough-dimension relay stops the feed of the grinding wheel as soon as a predetermined rough dimension is reached, and a final-dimension relay effects the withdrawal of the grinding wheel from the work and stops the machine when the final dimensions are obtained.



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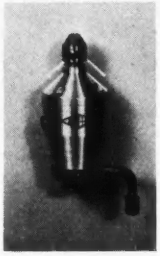

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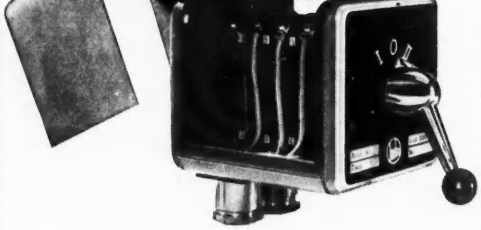

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Maschinen & Werkzeugfabrik A.G., vorm. H. Bossart, Reiden, showed a new design of high-duty radial drilling machine capable of drilling $1\frac{9}{16}$ in. diameter holes into solid 33-ton steel. The motor is rated at 4 hp. 18 spindle speeds between 45 and 2,335 rpm and 12 feeds of 0·0024-0·047 in. per revolution are provided. A maximum hole depth of $11\frac{3}{4}$ in. can be obtained without adjustment of the depth scale.

Meteor A.G., Zurich, are specialists in drill grinding machines. Among their exhibits, Type KBS deserves special mention. It is a machine for very small drills down to 0·008 in. diameter and embodies novel design principles, an optical system being built into the machine. The largest of the machines is suitable for drills ranging from $\frac{1}{8}$ to 4 in. diameter.

THE PHYSICAL CHARACTERISTICS OF D.C. GENERATORS

(*Concluded from p.* 153)

characteristics, they need further refinements to have a favourable dynamic behaviour. Unless an additional arrangement is provided, the main flux linked with the exciter winding will decrease with load, reaching a very low value under short-circuit conditions. On breaking off the short-circuit, the recurrent voltage pulse U_{op} is relatively small; it corresponds to the residual field and the voltage rises then gradually to its no-load value, according to the time-constant of the exciting circuit.

The hard-voltage system with auxiliary brushes should be particularly interesting for welding machines, since it avoids the use of separate excitation. The auxiliary brush can be moved to any required point away from the centre position, in order to make U_h dependent on the current, and this affects both the static and the dynamic characteristics.

FINAL REMARKS

Many other interesting designs based on the principles described in the above sections could also be mentioned. The cross-field machine has not been included because it could not easily be brought within the limits of this investigation. However, this should not be interpreted as an opinion on the merits of this machine.

Furthermore, in studying the physical conditions, the steepness of the curves considered has not been used as a characteristic for the assessment of the dynamic properties. When steepness is taken as a criterion, the short-circuit current is regarded as the determining quantity, although its significance is not primary but indirect, in regard to the welding properties, and is based on its relation with the suddenly recurring voltage. If, for example, the no-load voltage in a given machine reaches its full value immediately throughout the operating range, so that the dynamic behaviour is everywhere satisfactory, the steepness as a function of the welding current setting will, by definition, follow a hyperbolic law. However, if the dynamic behaviour of a machine deteriorates with increasing welding currents, this will be apparent as an increased steepness of its hyperbolic curve. Therefore, the steepness characteristic will not indicate directly whether the behaviour of a machine will improve or deteriorate with increased welding current. Instead, it is preferable to use a plotting of the impulse voltage against the welding current, expressing this voltage, for instance, as a percentage of the corresponding no-load voltage values. This gives a straight line parallel to the axis of the abscissae when the machine has the same dynamic behaviour throughout its working range, or a line with a positive or negative slope if the dynamic behaviour improves or worsens with increasing welding current. Moreover, the determination of the impulse voltage U_{op} by means of an "off-on-off" diagram is at least as simple as that of the steepness characteristic.

CHANGE WHEEL GEARING

REPRINT NOW AVAILABLE

Reprints of the article "Change Wheel Gearing," by O. Lichtwitz, M.I.Mech.E., are now available. Originally published in this journal in six instalments from January to June, 1950, the article has met with considerable interest among our readers. We have, therefore, decided to reprint it as a ready-reference work for all those concerned with change wheel gearing problems.

New readers of this journal may be interested to know that the treatise deals with various problems encountered in change gears. Some mathematical fundamentals required for their computation are condensed in a preparatory chapter, thus avoiding any break of sequence in the following sections, which deal with the computation proper. The method developed in these sections makes it possible to find gear trains with any specified accuracy, or to find the best solution obtainable with a given set of change wheels. It has frequently been found, after a gear train has been calculated, that it could not be mounted. The author demonstrates how a proper arrangement of the gears can readily be obtained without resorting to trial-and-error methods, and how such an arrangement, at the same time, ensures the least possible tooth loading.

Indexing when cutting multiple threads in a lathe introduces additional demands on the gear arrangement, and these problems are also dealt with.

The concluding chapter is devoted to the gearing of machine tools and contains ready-for-use tables for screw cutting, including metric and worm threads, which are often found to be troublesome.

An abridged factor table, which, however, meets the most exacting requirements, makes this booklet self-contained. A great number of examples from practice are worked out, and these should prove to be useful as a guide.

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NEWS OF THE MONTH

PERSONAL

Mr. Bernard Adkins, M.A.(Cantab.), M.I.E.E., A.M.Inst.C.E., Assoc.A.I.E.E., has been appointed to the University of London Readership in Electrical Engineering, Imperial College of Science and Technology.

Dr. C. F. Bareford, Head of the Mullard Electronic Research Laboratory, has been appointed a Director of Mullard Equipment Ltd.

Mr. H. D. Bell, having taken up permanent residence abroad, has resigned his directorship of Aberdare Cables Ltd. **Mr. J. P. Gilliver,** secretary, and **Mr. A. J. Nicholas,** director and general manager of South Wales Switchgear Ltd., have been appointed to the Board.

Mr. S. A. Cambray has been appointed joint managing director of John Allen & Ford (Wokingham) Ltd., Wokingham, Berkshire.

Mr. J. J. Carter, managing director of Crossley Brothers Ltd. for the past 35 years, retired on April 30th, but is continuing as a director of the Company and chairman of Crossley-Premier Engines Ltd. He is succeeded as managing director by **Mr. H. Desmond Carter, M.I.Mech.E., M.I.Mar.E.,** director and chief engineer of the Company.

Mr. A. G. Elliott, chief engineer and director of Rolls-Royce Ltd., Derby, has been appointed joint managing director with **Lord Hives, C.H.**

Mr. Vernon L. Farthing, M.I.Mech.E., M.I.Mar.E., M.Inst.P., has been elected Junior Vice-President of the Liverpool Engineering Society and President of the Liverpool Metallurgical Society.

Mr. Edward Hirst has resigned his positions as vice-chairman and joint managing director of the British General Electric Co. Pty. Ltd., owing to ill health, but will continue to serve as a director of the Company. **Sir Harry Brown** will continue as chairman, and **Mr. W. R. Caithness** and **Mr. T. E. Morgan** have been appointed joint managing directors.

Mr. C. Lovern, works manager of the Albert Street works of Joseph Sankey & Sons Ltd., Bilston, Staffordshire, has been appointed general manager in succession to **Mr. Walter van Helden** who retired on April 30, but retains his seat on the board of the Company. **Mr. Henry W. van Helden** has been appointed works manager.

Dr. W. L. Lowe-Brown, D.Eng., M.I.C.E., M.Am.Soc.C.E., has retired from the firm of Sir Murdoch MacDonald & Partners and has opened practice at 39 Victoria Street, London, S.W.1. Tel. ABBey 4150.

Mr. D. Maxwell Buist, M.I.E.E., export director of BEAMA, has been elected Chairman of the Council of the Institute of Export. **Mr. J. P. Ford,** director and general manager of Associated British Oil Engines (Export) Ltd., has been elected Vice-Chairman.

Mr. H. McConchie has been appointed manager of the new branch office of Newman Industries Ltd., Yate, Bristol, at 54 Merrion Street, Leeds.

Mr. J. D. Morton, M.I.Mech.E., M.I.E.E., has been appointed sales and technical manager of Siemens-Schuckert (Great Britain) Ltd., Faraday Works, Great West Road, Brentford, Middlesex.

Mr. Harold Parker, A.I.E.E., has been appointed managing director of Walter's Electrical Manufacturing Co. Ltd., Kensal Road, London, W.10, in succession to **Mr. E. E. Moore** who has now been elected Chairman of the Company.

Mr. H. V. Potter, B.Sc., F.R.I.C., M.I.Chem.E., chairman and managing director of Bakelite Ltd., has been elected Chairman, and **Mr. E. P. Hudson, M.A., F.R.S.E.,** director of Scottish Agricultural Industries Ltd., Vice-Chairman, of the Association of Chemical and Allied Employers. **Mr. F. J. Robinson, M.B.E., A.R.I.C., M.I.Chem.E.,** has been elected Vice-Chairman of the Plastics Group.

Mr. Austin Reynolds, B.A., A.M.I.Mech.E., A.F.R.Ae.S., has been elected President of the Aluminium Development Association. **Mr. H. G. Herrington** has been elected vice-president, and **Mr. F. G. Woollard, M.B.E., M.I.Mech.E., M.I.P.E.,** has been re-elected chairman of the executive committee.

Mr. L. L. Roberts, general manager of A. C. Cossor Ltd., Highbury Grove, London, N.5, and director and general manager of Cossor Radar Ltd., has resigned from these posts to take up an important position with Rootes Ltd., in connection with their export business.

Mr. F. E. Rowland, M.I.E.E., M.I.B.A.E., Member, A.S.A.E., manager of the Agricultural Department of The General Electric Co. Ltd., has been elected President of The Institution of British Agricultural Engineers.

Mr. E. A. Seeley has resigned his appointment as sales manager of Powder Metallurgy Division of Murex Ltd., Rainham, Essex. **Mr. B. E. Berry,** formerly Production Manager of the Powder Metallurgy Division, has been appointed production and sales manager of the Division and a director of Protolite Ltd., the Company's subsidiary organisation for the sale of Hard Metal products. **Mr. H. T. M. Roberts,** managing director of Protolite Ltd., will continue to take an active part in the sales of the products of the Powder Metallurgy Division, and will act as sales manager (London) for this Division.

The 1951 James Watt International Medal, recently awarded by the Council of the Institution of Mechanical Engineers —on the nomination of the Danish Society of Engineers—to Dr. H. H. Blache, of Denmark, for his contributions to the advancement of mechanical engineering, and particularly for his pioneer work in the development of the large marine Diesel engine, was presented to Dr. Blache at a general meeting of the Institution on Friday, 4th May.

The Danish Ambassador, Count Eduard Reventlow, was present at the ceremony, and the presentation was made by the President of the Institution of Mechanical Engineers, Mr. A. C. Hartley, C.B.E., B.Sc.(Eng.), M.I.Mech.E.

The James Watt International Medal was founded to commemorate the bi-centenary of the birth of James Watt, who was born on 19th January 1736. It is awarded biennially.

At the same meeting it was announced that Dr. Blache had been elected an Honorary Member of the Institution.

Mr. F. J. G. Petzoldt has been appointed Operation Research Engineer of the B.S.A. Tools Group, and his responsibilities will include improving efficiency and increasing production. His activities will also embrace design, planning, manufacturing, handling and despatch in all factories of the Group, with the exception of B. G. Machinery Ltd., and Cardiff Foundry & Engineering Co. (1947) Ltd.

OBITUARY

We record with regret the death of Mr. W. T. Hunter who was President of A. Schrader's Son, of Brooklyn, New York. On his frequent visits he made many friends in Great Britain. Mr. Hunter was instrumental in bringing about the amalgamation of Schrader's with the Scovill Manufacturing Company, and the general adoption of the Schrader tyre valve in world-wide use today was in great measure due to his efforts.

We announce with regret the death of Mr. Clifford Hobson, Manager of the Pump and Tank Department of The Dowson & Mason Gas Plant Co. Ltd., Levenshulme, Manchester 19. Mr. Hobson had formed many friendships during his 32 years connection with the Motor Trade, Transport and Oil Industries.

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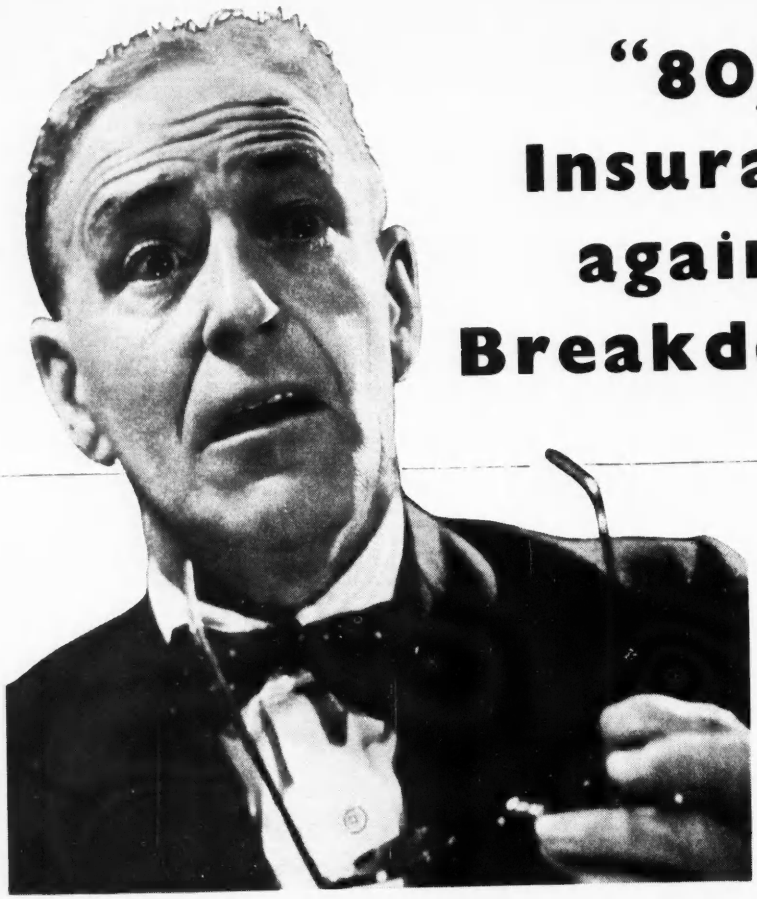

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BUSINESS NOTES

B.S.A. Tools Ltd. has purchased the entire plant of Machine Tools (Letchworth) Ltd., Stewart Works, Letchworth, Hertfordshire. Production of the Steinle Centreless Thread Generators and the Huller Tapping and Threading machines has been carried out at the Letchworth factory, which was controlled by the late Leo C. Steinle, and will continue at Letchworth. **Mr. J. E. Rogers,** who was works and general manager of Machine Tools (Letchworth) Ltd. for more than 10 years, has now been appointed works manager of the Letchworth Branch of B.S.A. Tools Ltd., and all other members of that Company have also been retained by B.S.A. Tools Ltd. Machine Tools (Letchworth) Ltd. will continue its business at Salisbury.

Burton, Griffiths & Co. Ltd. have terminated the agency arrangements with Gilbert & Murphy, their agents for Eire and N. Ireland, by mutual agreement. The machine tool interests of the Company will be taken care of by own representatives from the Head Office.

Grinding Coolants. A marked improvement in grinding finishes can be obtained by adding an extremely small percentage of "dag" colloidal graphite in the form of Coating Solution Product 529 to grinding coolants.

Originally used to eliminate grinding cracks which tend to occur when working certain steels, the improvement in finish which results, coupled with the reduction in tool wear makes the use of this product generally beneficial in all grinding operations.

Acheson Colloids Limited, 18 Pall Mall, London, S.W.1, have issued Information Sheet No. S.2 on this subject which they will be pleased to send to all who are interested.

Howard Clayton-Wright Ltd., Wellesbourne, Warwickshire, announce that their firm and its associated companies are not in any way associated with any concern making similar products, and, in particular, Flexible Bearings.

Alfred Imhof Ltd., 112-116 New Oxford Street, London, W.C.1, announce that the design of their Enclosed Rack has now been registered and has been officially approved for many purposes by the M.O.S., R.A.F., Admiralty, G.P.O., etc.

Insley (London) Ltd., 119 Oxford Street, London, W.1, has been appointed sole distributor for the United Kingdom and the British Commonwealth for Hydrel A.G., Romanshorn, Switzerland, manufacturers of needle bearings. The company has also been appointed representative for KFA Kugellagerfabrik A.G., Arbon, Switzerland, manufacturers of ball bearings.

Newman Industries Ltd., of Yate, Bristol, have been appointed Sole Selling Agents for the United Kingdom for "Heid" centre lathes and copying lathes.

Pegson Limited, of Coalville, announce that the Chairman and Managing Director, Mr. W. L. James, who recently returned from a visit to the United States, has been successful in securing the manufacturing rights for the United Kingdom and Commonwealth, of a world-famous patented machine, which is used in mines and quarries for the continuous production of fine mesh products from a coarse feed. Pegson Ltd. will build the machine in several sizes and in various types.

Stordy Engineering Ltd. have moved to more commodious premises. The new address is Cumbria House, Goldthorn Hill, Wolverhampton. Tel. Nos. 37341-2.

BRITISH PURCHASING COMMISSION FOR EUROPE

Britain is setting up a European Purchasing Commission under the direction of the Minister of Supply (Mr. George R. Strauss) to encourage the procurement in Europe of stores and equipment required for the U.K. Defence Programme.

The placing of orders in Europe to supplement production in this country will confer mutual benefits. It will :—

(1) help European countries of the North Atlantic Treaty Organisation to develop their capacity to fulfil their own defence programmes ;
(2) benefit their balance of payments and general economy, and
(3) enable British manufacturing capacity to be used for essential home production and exports to a greater extent than the substantial re-armament programme would otherwise permit.

The Commission will operate in Europe for all Government Departments concerned in the Defence Programme, and will advise manufacturers wishing to place sub-contracts in Europe.

The type of equipment required include : heavy and light engineering products ; textiles ; hardware ; leather goods and items of ancillary equipment.

The Chairman of the Commission is Sir Donald Perrott, K.B.E., Deputy Chairman of the Overseas Food Corporation since 1949, and the Deputy Chairman is Captain K. J. G. Bartlett, a Director of the Bristol Aeroplane Co. Ltd. They will be assisted by an advisory panel of experienced industrialists. They are Sir Francis Brake, Deputy Chairman of the British-South American Airways Corporation ; Managing Director of Creed & Co. Ltd. ; Vice-President of International Standard Electric Corporation ; Director of Standard Telephones and Cables and Director of International Marine Radio Co., Mr. A. G. E. Briggs, A.M.I.Mech.E., Assistant Managing Director of Tube Investments Ltd., Deputy Controller of Supplies (Munitions) Production, Mr. W. C. Puckey, M.I.P.E., F.I.I.A., Director and General Works Manager of Hoover Ltd., Deputy Controller of Supplies (Aircraft) Production ; Mr. S. W. Rawson, Managing Director of John Brown & Co., Director of Thomas Firth & John Brown Ltd., Firth-Brown Tools Ltd., and more than 20 companies engaged in engineering and ship-building,

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There are 16 numbered sheets to the Set in blueprint form, 8" × 10" notebook size, and punched to fit a special binder which is also supplied, and into which loose-leaf notepaper can be fastened to make the binder into a very comprehensive notebook.
Other drawings will be made available later, and there is no doubt that if the folder is kept up-to-date, together with your own notes it will become a really valuable Compendium of Engineers' Precision Tools.

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Sir Alan Saunders, Chairman of the British Sugar Corporation, and Mr. E. W. Senior, Chairman of George Senior & Sons Ltd., Commercial Director of the Iron and Steel Federation, Chairman, Steel (Re-armament) Advisory Panel. Mr. C. S. Goad (Ministry of Supply) will be Secretary of the Commission.

The Commission will have offices in a number of the main European countries.

All inquiries on orders to be placed in Europe and to European potential should be addressed to :—

The European Purchasing Commission, Ministry of Supply, Adelphi, John Adam Street, London, W.C.2.

PROPELLERS OF THE FUTURE

Despite the advent of the turbojet engine, propellers are still in demand for certain types of aircraft and certain roles. British designers are now breaking fresh ground with propellers of new shapes and sizes to transmit the enormous powers of the latest gas-turbine engines.

de Havilland's are now running on the test-bed an eight-bladed contra-rotating propeller which will give about the same thrust at take-off as all four pure-jet engines of the *Comet* put together.

Engineers at Hatfield are also studying designs for blades which will operate efficiently on aircraft cruising at 600 miles-an-hour. These propellers, whose blade-tips would be travelling at 1½ times or twice the speed of sound, would probably be wafer-thin steel four-blade units—giving high take-off thrust with very economic fuel consumption at high-speed.

With the high horse-powers of the present day, the designer's problem is one of weight. He is forced to increase the blade area to such a point that it is impossible to use conventional duralumin material and still keep within a reasonable weight-limit. The problem is particularly marked with propellers of more than about 14 ft. in diameter. Wood, the other customary propeller material, is, of course, far too weak.

Current research has centred on the hollow-steel blade. Technicians are now convinced that the hollow-steel blade saves some 12 to 15 per cent in weight over any solid alloy blade of the same design and gives 20 per cent more static thrust than any solid airscrew of the same weight.

The new blade is made by fitting a tubular steel core into a thin outer blade-shaped shell of sheet steel. The core is sheathed in the shell in a 1,000 ton press after heating in an electric furnace and then shaped by filling it with nitrogen under pressure. The gap between core and shell is filled with a rubber foam compound. When the whole blade has been sealed, the root-end is hardened in an induction heater to give a hard surface which will restrain the blade against centrifugal load.

The heater used at Hatfield is the largest in the country, and probably in the world. The advantage of this type of heating is that it can be turned on or off by flicking a switch and can be completely localized—the principle being that the machine induces a high-frequency current in the object to be heated. Thus the root-end of the blade can be heat-treated without affecting the temperature of any other part of the blade or material. As an example it would be possible to heat a nail in a paper bag up to several hundred degrees without burning the paper bag.

These new machines and manufacturing processes are necessary because the propeller is essentially a precision aerodynamic and mechanical product and not merely a standard accessory. Each new type of engine or aircraft calls for a distinctive blade tailor-made to suit it. Every change in power and vibration in an engine, its mounting and its performance, immediately affects the propeller.

The precision checking of each production blade is backed by a complicated series of bench tests and vibration checks of experimental and finished propellers. Proof of this is that whereas the de Havilland Propeller Co., built about 1,500 production propellers last year, they also ran another 265 propellers for a total of 7,400 hours for development.

The tests are designed to put a propeller through all the conditions of service before it actually goes into airline or service operation. Machines vibrate the airscrew hub through a wide range of conditions and plot the pattern of vibratory forces by electrical strain gauges. Fatigue is tested by vibrating a blade through hundreds of millions of reversals. Checking the results of these tests from graphs and drawings by ordinary calculation takes months, so an electric computor has been designed which can solve twelve simultaneous equations in twelve variables—and cut down the time for working out results (not, of course, the tests themselves) to less than a week.

INDUSTRIAL EXHIBITS OF POWER SHOW

More than 750 British products ranging in size from a 187-ton export locomotive to a hypodermic needle have been assembled to illustrate the story of Britain's achievement in heavy engineering to be told in the Exhibition of Industrial Power in the Kelvin Hall, Glasgow, from May 28 to August 18. These exhibits have been chosen by the Council of Industrial Design in consultation with Trade Associations to combine the tasks of illustrating points in the story with that of showing the world the finest expressions of British engineering skill.

For the technicians the high spots of the Exhibition will be :

The opportunity of studying the latest types of British coal cutting, loading, conveying and hauling equipment operated in working conditions by teams of skilled Scots miners.

Here too they will see latest most efficient forms of lighting and safety devices.

The floor of the Steel Hall will be a catalogue in itself of the almost infinite variety of rolled steel sections produced in Britain.

In the Hall of Steel a fully equipped machine shop fitted with a battery of the latest machine tools will be in full operation on productive work progressed according to the best modern practice.

In the same section there will be a sequence devoted to the principles of standardisation, describing how these have been carried forward in recent times towards an almost universal application.

Keynote of the Power for Industry Hall will be the unremitting quest for fuel efficiency starting with James Watt and continuing through the steam turbine to the latest types of economisers. Also on view in this hall will be a heavy oil engine and a display of the latest and most efficient steam-raising equipment made in Britain.

The Hall of Electricity illustrates the outstanding contribution Britain has made to electrical knowledge from the days of Faraday onwards and houses a large display of modern industrial exhibits.

The Hall of Civil Engineering traces the history of structure from the days of the master-builder working in stone and timber to the modern engineer with steel, aluminium, and pre-stressed concrete at his command. It also covers water supply, tunnelling, and docks and harbours.

The Hall of Hydro-Electricity examines in detail the North of Scotland hydro scheme, and shows not only how the dams and power stations are being built, but the effect they are already having on the people of the Highlands.

Finally in the great Hall of Shipbuilding and Railways the technical and lay interests are almost balanced. For the technician there will be radar, echo sounding and a completely equipped ship's engine room ; for the lay visitor the visual effect of a 35-foot high ship's bows towering to the roof trusses of the Kelvin Hall and a vista worthily illustrating the vast scope of the subject.

"TIN GOES AHEAD"

The Duke of Gloucester will open the new Laboratories of the Tin Research Institute at Greenford on Thursday afternoon, May 31st. Diplomatic representatives of tin-producing and consuming countries and many distinguished scientists and industrialists will be present. On Friday, June 1st, the Laboratories will be open all day for inspection.

Visitors will see for the first time a new electroplate " Tin-nickel " which was discovered at the Institute. It is an alloy made by the simultaneous deposition of two parts of tin to one part of nickel. The electroplating process is simple and trouble-free and the coating is permanently brilliant under adverse outdoor conditions. The colour tone of the tin-nickel plate is a faint rose.

Tin-nickel is being shown as a decorative and protective finish upon a wide range of motor car and cycle accessories, tableware and cutlery, bathroom fittings, brush, comb and mirror sets, door and cabinet handles, locks and hinges, cigarette lighters and ash-trays. Tin-nickel must be considered a serious rival to chromium.

In addition to tin-nickel there will be seen five other alloy platings all invented in the Institute's laboratories.

Other sections of the Laboratories will demonstrate their research work on hot-dip tinning, soldering and the mechanical testing of tin alloys, including babbitt metals.

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BOOKS

THE EUROPEAN ENGINEERING INDUSTRY

The Industry and Materials Committee of the United Nations Economic Commission for Europe has just published "A General Survey of the European Engineering Industry." It is an important work of greatest interest and importance, as it presents in a single volume not only the latest statistical data in connection with the various engineering industries of 15 European countries, but it is at the same time an analytical study of some of the economical problems of these industries.

The Survey covers the following sectors of industrial activity: Road and Rail Transport equipment; Water Transport equipment; Heavy Electric Power Plant; Electric equipment; Electronic and Signalling equipment; Mining and Quarrying equipment; Iron and Steel Making equipment; Machine Tools; Tractors and Agricultural Machinery; Forestry and Woodworking equipment; Building and Construction equipment; Mechanical Handling equipment; Textile Machinery; Chemical and Food Processing equipment.

Some of the interesting chapters deal with the General Course of Trade, Overseas Exports of European Engineering Products; European Imports of Engineering Products from the U.S.A.; Trends in Specialisation between countries and in sectors; Possible Course of Demand in certain regions; Possible Eastern European Import Requirements in 1953.

Executives in the engineering industries will derive much benefit from study of this carefully edited volume.

Electric Power Stations. By T. H. Carr. Foreword by the late Sir Leonard Pearce. Vol. II. 3rd edition revised and enlarged. 820 pp. 624 illustrations. Publishers: Chapman & Hall, Ltd., 37 Essex Street, London, W.C.2. Price 75/-.

Engineering Metrology. By K. J. Hume. 293 pp. 123 illustrations. Publishers: Macdonald & Co. (Publishers) Ltd., 43 Ludgate Hill, London, E.C.4. Price 18/-.

Displacement Pumps and Motors. By R. Hadekel. 172 pp. 177 illustrations. Publishers: Sir Isaac Pitman & Sons Ltd., Parker Street, Kingsway, London, W.C.2. Price 25/-.

Mathematical Solution of Engineering Problems. By J. Jennings. 205 pp. 79 figures. Publishers: E. & F. N. Spon Ltd., 22 Henrietta Street, London, W.C.2. Price 25/-.

Conductimetric Analysis at Radio-Frequency. By G. G. Blake. 109 pp. 40 illustrations. Publishers: Chapman & Hall Ltd., 37 Essex Street, London, W.C.2. Price 15/-.

BRITISH STANDARDS

(*Copies of British Standards may be obtained from the British Standards Institution, 24, Victoria Street, London, S.W.*1.)

Thermodynamic Properties of Refrigerants (B.S. 1725 : 1951) gives tables of thermodynamic properties of the following refrigerants: ammonia, sulphur dioxide, carbon dioxide, methyl chloride and dichlorodifluoromethane. Tables of the properties of saturated vapour and superheated vapour for each of the above refrigerants are included in this standard. The tables of the properties of ammonia, methyl chloride, sulphur dioxide and dichlorodifluoromethane have been reproduced from data published in various journals in the United States of America. Tables of properties of carbon dioxide have been obtained from sources in this country. These tables are reproduced by permission of the various authorities and acknowledgement to them is given in the Introduction to the standard. An Appendix has also been included giving a list of references from which details of thermodynamic properties of refrigerants, not covered by this British Standard may be obtained. Price 10/6.

Steel Tubes for Cycle and Motor Cycle Purposes (B.S. 1717 : 1951). Three types of steel tube are covered: cold drawn seamless, electric resistance butt-welded, and cold drawn electric resistance butt-welded. Within each type a number of grades are specified. A general section lays down such requirements as the procedure for mechanical testing and dimensional tolerances, including straightness.

A table at the end of the standard gives a useful summary of the chemical compositions and mechanical properties of the complete range of tubes. Price 2/6.

"Brazing" (B.S. 1723 : 1951). The standard is confined to those aspects of brazing for which it is considered advisable to specify definite requirements although general recommendations regarding the features of one or more methods of brazing are given where it is thought that guidance will be helpful. In view of the vast range of joints and connections for which brazing is used this treatment of the subject has been considered the most appropriate.

The brazing processes covered are blowpipe (torch), furnace, electric induction, electric resistance, dip and salt bath.

A general section specifies requirements for joint design, general preparation, flux removal, inspection and testing procedure. Each process is dealt with in a separate section in terms of a description of the processes and the permissible filler metals for the various parent metals. Price 3/-.

Nomenclature of Drawing Instruments (B.S. 1709 : 1951) gives names and descriptions of over eighty drawing instruments. Compasses are dealt with first, these being divided into six classes, i.e. half sets, compasses, dividers, bows, bow half sets and spring bows, each of which is defined.

The remaining instruments are sub-divided into five classes, i.e. ruling pins, prickers, steel tracers, beam compasses and proportional dividers, a description of each instrument being given. The scales most commonly appearing on proportional dividers are included in an appendix. Price 2/-.

Classified Advertisements.

The rate for all classified advertisements is 6d. per word; in bold print 9d. per word; minimum order 6s. Box number advertisements 1s. extra. Instructions together with remittance must be received not later than the 3rd of each month for advertisements to appear in the same month's issue.

SITUATIONS VACANT

ADMIRALTY (CIVIL ENGINEER-IN-CHIEF'S DEPARTMENT)

Immediate vacancies exist for Leading Architectural and Civil Engineering Assistants in the Drawing Offices at the following establishments, Pinner (N.W. London), Leeds, Glasgow, Lossiemouth (N.E. Scotland) and Arbroath (N.E. Scotland). In addition there are likely to be vacancies at all Admiralty Establishments in this country and Northern Ireland with opportunities for service in Admiralty Dockyards overseas.

Applicants must be competent draughtsmen and designers with experience in some of the following types of Building and Civil Engineering Structures and Works.

Structural Steelwork, Reinforced Concrete, Dock and Harbour Works, Accommodation, Residential, Office, Store and Factory Buildings, Oil Fuel Tanks and Pipe Lines, Airfield Construction and Maintenance, Rail, Road, Water sewerage and Heating Services, etc.

The salary range is £570 p.a. × £20 p.a.—£675 p.a. The rates quoted are "London" rates and are slightly lower in the provinces. In addition appropriate rates of Foreign Service Allowance are payable at Stations abroad.

The appointments are temporary.

Applications should be made giving full particulars of experience to the Civil Engineer-in-Chief, Admiralty, Chamberlain Way, Pinner, Middlesex.

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WANTED.—240V Single Phase Light Alloy Spot Welder.—**V.P. Sheet Metal Ltd.,** Windsor Street, Cheltenham. 'Phone: Cheltenham 5805-6.

WANTED.—Back issues of THE ENGINEERS' DIGEST for March, 1951, urgently required. Full price, 3/6 will be paid for each copy. Send copies to the **Subscription Department, "The Engineers' Digest,"** 120, Wigmore Street, London, W.1.

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FULL STEAM IN FIVE MINUTES with B & A Electrode Boilers, used by British industries for 20 years. No boilerhouse, no flue, no attendant needed. The most compact and convenient steam raisers available, can go beside machines using the steam. Write for leaflet 127, **Bastian and Allen Ltd.,** Ferndale Terrace, Harrow, Middlesex.

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